ATLAS OF ZEOLITE FRAMEWORK TYPES

Ch. Baerlocher
W.M. Meier
D.H. Olson

Fifth Revised Edition
2001

Published on behalf of the
Structure Commission of the International Zeolite Association

ELSEVIER

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PREFACE

A forerunner of the ATLAS was first published in 1970[1]. This early survey comprised 27 zeolite structures known at the time. Then the "Atlas of Zeolite Structure Types" by W.M. Meier and D.H. Olson, with 38 entries, was published by the Structure Commission of the IZA in 1978. This was followed by the much expanded 2nd edition of the ATLAS in 1988 comprising 64 entries, the updated 3rd edition in 1992 with 85 entries, and the fully revised 4th edition in 1996 with 98 entries. This 5th edition is again an updated version of the previous compilation, and the number of entries has risen significantly to 133.

The ATLAS contains an entry for each unique zeolite framework type. The term zeolite framework refers to a corner-sharing network of tetrahedrally coordinated atoms. In compliance with the changes in zeolite nomenclature recommended by IUPAC in 2001[2] the title of the Atlas had to be changed from ‘Atlas of Zeolite Structure Types’ to ‘Atlas of Zeolite Framework Types’. This is because the term 'structure' implies both the framework and the extra-framework constituents of a zeolite and the latter are excluded in the framework description.

As a frequently quoted work of reference, the ATLAS must be updated on a regular basis to be of full use. Not only must new framework types be added, but corrections and new information on existing entries must also be disseminated. This compilation is based on information that was available to the authors by the end of 2000. We have been very grateful for preprints and unpublished data in a number of instances and this is acknowledged on the respective pages. New framework types (formerly called structure types) will be published on the world wide web (http://www.iza-structure.org/databases/) as they are approved.

To make it easier for the reader we have rearranged some of the data and prepared new stereo drawings. We have separated the information pertinent to the Framework Type from that corresponding to the Type Material only. In addition, we have included idealized cell parameters for the framework types, added the vertex symbols for each T–atom in a framework and have re-introduced the secondary building units (SBU's) which had been dropped in the 4th edition. The data sheets have all been generated from a zeolite database built by Ch. Baerlocher and L.B. McCusker using the contents of the 4th edition of the ATLAS as a basis. This zeolite database is also used to publish the data on the world wide web under http://www.iza-structure.org/databases/.

We wish to acknowledge the assistance and collaboration of many fellow scientists in our field. We are indebted to the members of the IZA Structure Commission for their extensive proof reading and for providing additional information. In particular we wish to express our appreciation to Dr. Lynne McCusker for maintaining the reference database, for her help in preparing the stereo drawings and last but not least for her highly valued advice throughout this work. It does not seem possible to assemble such a compilation absolutely free of errors, so the authors will be grateful for any additions and/or corrections for future updates.

February 2001 Ch. Baerlocher W.M. Meier D.H. Olson

Structure Commission of the International Zeolite Association

Previous IZA Special Publications:

- W.J. Mortier, "Compilation of Extra Framework Sites in Zeolites" (1982)
- W.M. Meier and D.H. Olson, "Atlas of Zeolite Structure Types", 2nd edition (1987)
- W.M. Meier and D.H. Olson, "Atlas of Zeolite Structure Types", 3rd edition (1992)
- W.M. Meier , D.H. Olson and Ch. Baerlocher, “Atlas of Zeolite Structure Types”, 4th edition (1996)
- R. von Ballmoos and J.B. Higgins, "Collection of Simulated XRD Powder Patterns for Zeolites", 2nd edition (1990)
- M.M.J. Treacy, J.B. Higgins and R. von Ballmoos, "Collection of Simulated XRD Powder Patterns for Zeolites", 3rd edition (1996)
- H. Robson and K.P. Lillerud, "Verified Synthesis of Zeolitic Materials" (1998)

INTRODUCTION AND EXPLANATORY NOTES

Zeolites and zeolite-like materials do not comprise an easily definable family of crystalline solids. A simple criterion for distinguishing zeolites and zeolite-like materials from denser tectosilicates is based on the framework density (FD), the number of tetrahedrally coordinated atoms (T-atoms) per 1000 $Å^3$. Figure 1 shows the distribution of these values for porous and dense frameworks whose structures are well established[(3)]. A gap is clearly recognizable between zeolite-type and dense tetrahedral framework structures. The lower boundary ranges from 19 to over 21 T-atoms per 1000 $Å^3$, depending on the type of smallest rings present. Strictly speaking the boundaries defined in Figure 1 for the framework densities apply to fully crosslinked frameworks only. Therefore, Figure 1 does not include interrupted frameworks.

For each framework type code (see below), two pages of data are included in the ATLAS. The left hand page lists the information that characterizes the framework type. This includes crystallographic data (highest possible space group, cell constants of the idealized framework), coordination sequences, vertex symbols and loop configurations. Taken together the last three pieces of information define the framework type. On the second page, data for the type *material* (i.e. a real material) can be found. Although the channel dimensionality is a property of the framework type, the channel description also includes the observed ring dimensions, and must therefore refer to the type material. For all framework types, a list of isotypic materials and their references are also given. The different entries in the data sheets are described in more detail below in the order in which they appear on these pages.

Framework Type Page

Framework type codes (previously called structure type codes)

Following the rules set up by an IUPAC Commission on Zeolite Nomenclature in 1978[(4)], designations consisting of three capital letters (in bold face type) have been used throughout. The codes are generally derived from the names of the type materials (see Appendix D) and do not include numbers and characters other than capital Roman letters. The assignment of Framework Type codes is subject to review and clearance by the IZA Structure Commission according to a decision of the IZA Council (taken at the time of the 7th IZC in Tokyo, 1986). Codes are only assigned to established structures that satisfy the rules of the IZA Structure Commission (see Appendix B for a listing of these rules). For interrupted frameworks, the 3-letter code is preceded by a hyphen. These mnemonic codes should not be confused or equated with actual materials. They only describe and define the network of the corner sharing tetrahedrally coordinated framework atoms. Thus, designations such as NaFAU are untenable. However, a material can be described using the IUPAC crystal chemical formula[(2)], as **|**Na_{58}**|** **[**$Al_{58}Si_{134}\,O_{384}$**]-FAU** or **|**Na-**|** **[**Al-Si-O**]-FAU** (Note that the chemical elements must be enclosed within the appropriate brackets, i.e. **| |** for guest species and **[ ]** for the framework host). Framework types do not depend on composition, distribution of the T-atoms (Si, Al, P, Ga, Ge, B, Be, etc.), cell dimensions or symmetry.

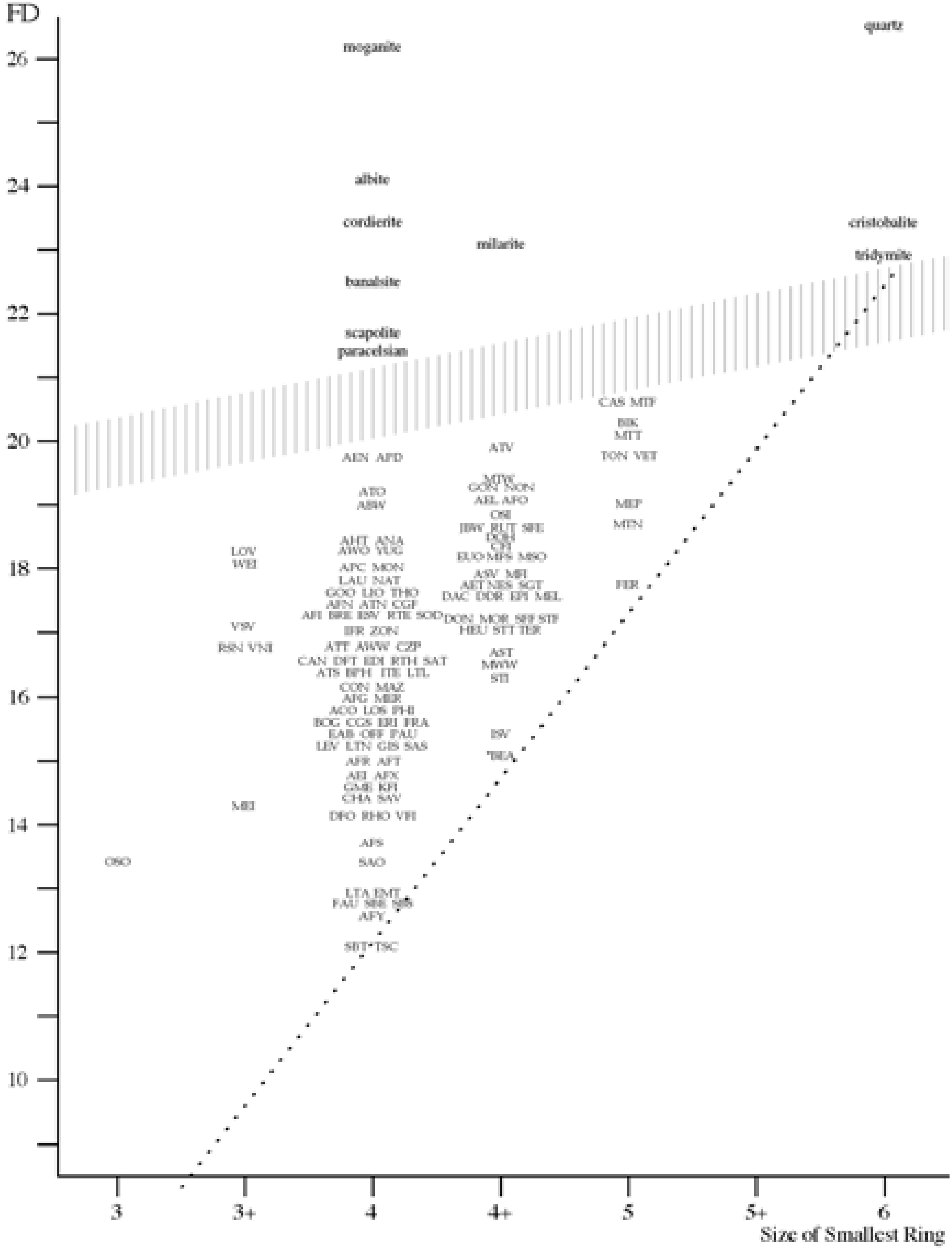


Fig. 1. Framework density vs. smallest ring in loop configuration. The + sign indicates that there are some T–positions associated with only larger rings (See Loop Configurations).

The framework types have been arranged in alphabetical order according to the framework type code, because structural criteria alone do not provide an unambiguous classification scheme. This also facilitates later insertion of new codes and allows simple indexing. The framework type code is given at the top of each page. On the left hand page this is supplemented with the maximum space group symmetry for the framework, and on the right hand page with the full name of the type material.

Idealized cell parameters

The idealized cell parameters are obtained from a DLS-refinement(5) in the given (highest possible) symmetry for the framework type. The refinement was carried out assuming a (sometimes hypothetical) SiO_2 composition and with the following prescribed interatomic distances: $d_{Si\text{-}O}$ = 1.61Å, $d_{O\text{-}O}$ = 2.629Å and $d_{Si\text{-}Si}$ = 3.07Å using the weights of 2.0, 0.61 and 0.23, respectively.

Coordination sequences (CS) and vertex symbols

The concept of coordination sequences was originally introduced by Brunner and Laves(6) and first applied to zeolite frameworks by Meier and Moeck(7). In a typical zeolite framework, each T-atom is connected to N_1 = 4 neighboring T–atoms through oxygen bridges. These neighboring T-atoms are then linked in the same manner to N_2 T-atoms in the next shell. The latter are connected with N_3 T–atoms etc. Each T–atom is counted only once. In this way, a coordination sequence can be determined for each T-atom of the 4-connected net of T-atoms. It follows that

$N_0 = 1$ N_1 £ 4 N_2 £ 12 N_3 £ 36... N_k £ $4 \cdot 3^{k-1}$

CS's are listed from N_1 up to N_{10} for each topologically distinct T–atom in the framework structure along with the site multiplicity and the site symmetry (both in parenthesis).

The vertex symbol was first used in connection with zeolite-type networks by M. O'Keeffe and S.T. Hyde(8). This symbol indicates the size of the smallest ring associated with each of the 6 angles of a tetrahedron (T–atom). The symbols for opposite pairs of angles are grouped together. For **FAU** the vertex symbol reads 4.4.4.6.6.12, indicating that one pair of opposite angles contains 4-rings, a second pair contains a 4-ring and a 6-ring, and the final pair of opposite angles contains a 6-ring and a 12-ring. It is useful for determining the smallest rings in a framework. In the case of **DOH**, for example, these are 4- and 5-rings, i.e. 4+. Sometimes more than one ring of the same size is found at a vertex.. This is indicated by a subscript like 6_2 or 8_2.

The coordination sequence and the vertex symbol together appear to be unique for a particular framework topology, i.e. they can be used to distinguish different zeolite framework types unambiguously. In this way, isotypic frameworks can be easily recognized.

Secondary building units (SBU's)

Zeolite frameworks can be thought to consist of finite or infinite (i.e. chain- or layer-like) component units. The finite units which have been found to occur in tetrahedral frameworks are shown in Figure 2. These secondary building units[a], which contain up to 16 T-atoms, are derived

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[a] The primary building units are single TO_4 tetrahedra.

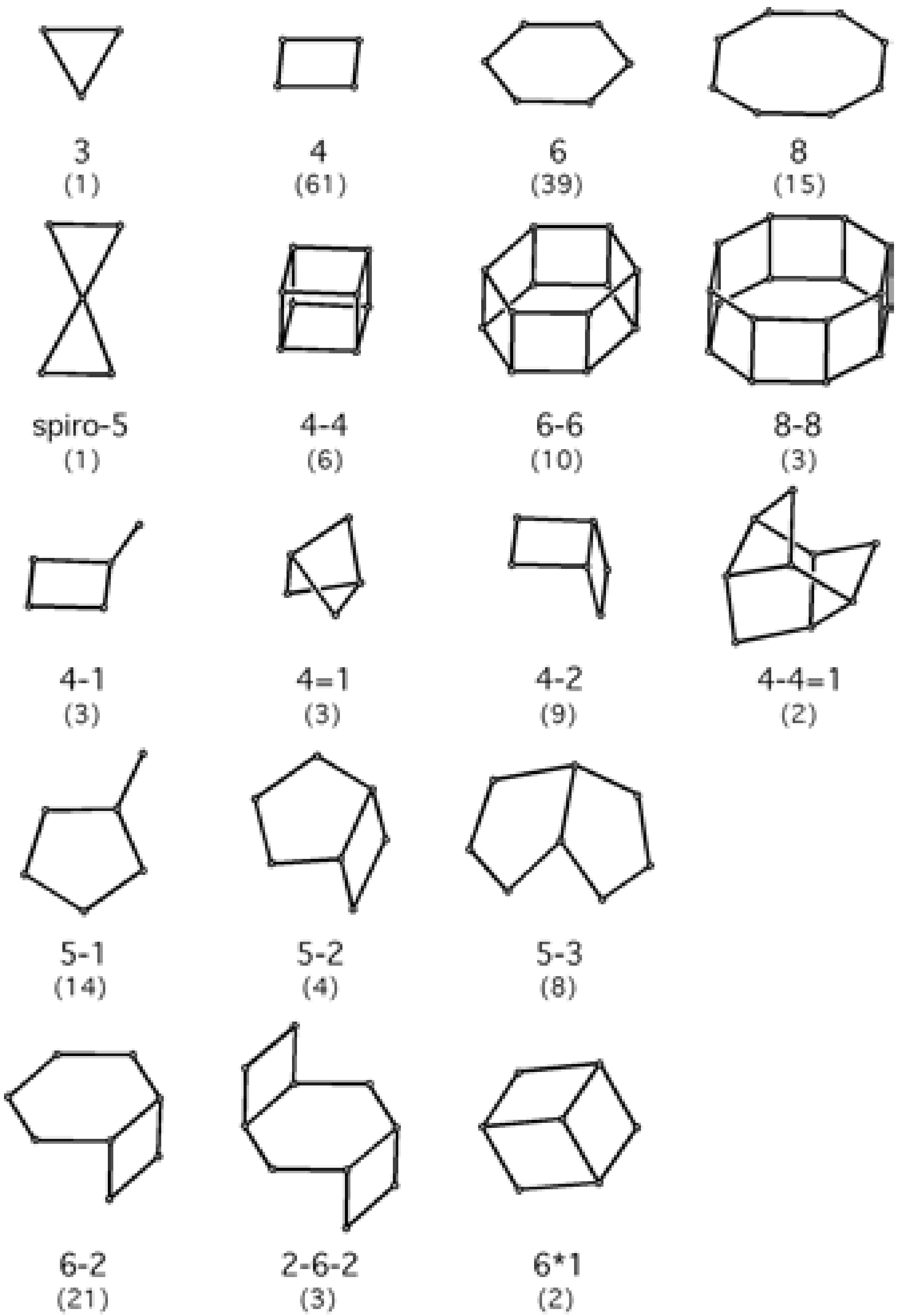


Fig. 2. Secondary building units and their symbols. Number in parenthesis = frequency of occurrence.

assuming that the entire framework is made up of one type of SBU only. It should be noted that SBU's are invariably non-chiral[a]. A unit cell always contains an integral number of SBU's. As far as practicable, all possible SBU's have been listed. The number of observed SBU's has increased from 16 in 1992 to 20 at present. In some instances, combinations of SBU's have been encountered. These

[a] This means that SBU's in the isolated state of highest symmetry are neither left- nor right-handed.

have not been listed *in extenso* because this can arbitrary. The symbols given below the drawings in Figure 2 are used in the data sheets to describe the SBU's. If more than one SBU is possible for a given framework type, all are listed. The number given in parenthesis in Figure 2 indicates the frequency of the occurrence of that SBU.

The SBU's are only theoretical topological building units and should not be considered to be or equated with species that may be in the solution/gel during the crystallization of a zeolitic material.

Loop configuration of T-atoms

The loop configuration is a simple graph showing how many 3- or 4-membered rings a given T–atom is involved in. Solid lines represent T–O–T linkages whereas dotted lines indicate non-connected T-O bonds found in interrupted frameworks. Sato(9) used the term "second coordination networks". Loop configurations are likely to be of interest to spectroscopists. These data can also be used for classification purposes and for deducing rules relating to these structures which might be of predictive value(10). Figure 3 shows all observed loop configurations and their frequency of occurrence. The information given in the loop configuration is a subset of the vertex symbol.

Framework description

For all 15 framework types belonging to the so-called ABC-6-family the ABC stacking sequence is listed here. Listed are also some other structural relationships which are thought to be helpful.

Isotypic framework structures

Under this heading as-synthesized materials that have the same framework type but different chemical composition or have a different laboratory code are listed. Materials obtained by post synthesis treatment (e.g. ion exchange, dealumination, etc.) are generally not included. The type material (defined on the right hand page) is given first and marked with an asterisk. Isotypic species, which have sometimes been termed "homeotypic"(11), are very frequent and are also listed in the isotypic material index.

Zeolite-type silicates and phosphates apparently constitute two distinctive categories of microporous materials. Table 1 (which is based on the isotypes listed in the ATLAS) shows, however, that there are three, rather than two distinct groups of framework types. Apart from those associated with silicates and phosphates there is a sizable group of structure types which have been found to occur both in silicates and phosphates.

References

The list of references cited is far from complete. As a general rule, references to the type materials are to the work first establishing that framework type and to subsequent work adding significant information regarding the framework topology. Thus papers on non-framework species have not been included. References to isotypes are limited to the work in which sufficient data are provided to establish the identity.

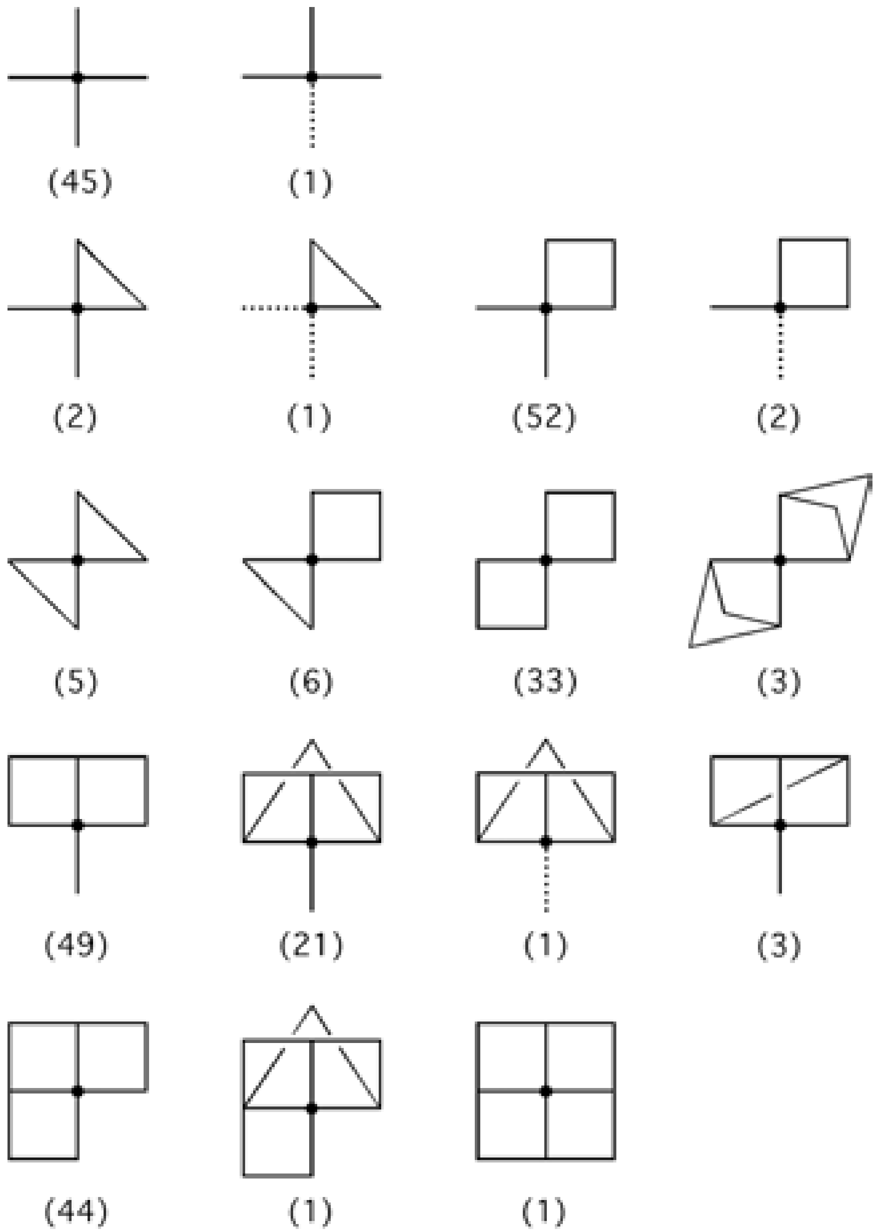


Fig. 3. Loop configurations. Number in parenthesis = frequency of occurrence.

For the 42 codes from **ABW** to **CZP**, complete references, cell constant data, space groups, site symmetries, symmetry relationships, structural diagrams, positional coordinates for all types and chemical compositions for all crystal structure determinations published up to April 2000 are to be found in: W.H. Baur and R.X. Fischer: Zeolite-Type Crystal Structures and their Chemistry[12].

Table 1: Microporous zeolite-type materials

Silicates[a]			Both Silicates and Phosphates	Phosphates[b]	
AFG	IFR	OFF	ABW	ACO	SAO
ASV	ISV	OSO	AET	AEI	SAS
*BEA	ITE	-PAR	AFI	AEL	SAT
BIK	JBW	PAU	AFX	AEN	SAV
BOG	KFI	-RON	ANA	AFN	SBE
BRE	LIO	RSN	AST	AFO	SBS
CAS	LOV	RTE	BPH	AFR	SBT
CFI	LTN	RTH	CAN	AFS	VFI
-CHI	MAZ	RUT	CGS	AFT	WEI
CON	MEI	SFE	CHA	AFY	ZON
DAC	MEL	SFF	DFT	AHT	
DDR	MEP	SGT	EDI	APC	
DOH	MFI	STF	ERI	APD	
DON	MFS	STI	FAU	ATN	
EAB	MON	STT	GIS	ATO	
EMT	MOR	TER	LAU	ATS	
EPI	MSO	TON	LEV	ATT	
ESV	MTF	TSC	LOS	ATV	
EUO	MTN	VET	LTA	AWO	
FER	MTT	VNI	LTL	AWW	
FRA	MTW	VSV	MER	CGF	
GME	MWW	-WEN	PHI	-CLO	
GON	NAT	YUG	RHO	CZP	
GOO	NES		SOD	DFO	
HEU	NON		THO	OSI	

[a] including germanates
[b] including arsenates

Type Material Page

The type material is the species first used to establish the framework type. Detailed information about the material is given on this page.

Crystal chemical data

The composition, expressed in terms of cell contents, has been idealized where necessary for simplicity. The chemical formula is given according to the new IUPAC rules[2]. The space group and cell parameters listed for each type material are those taken from the reference cited. In many instances, further refinement of the structure taking into account ordering etc. would yield a lower symmetry. It should also be noted that the space group and other crystallographic data related to the type material structure do not necessarily apply to isotypes.

In some cases, the space group setting of the type material differs from that of the framework type. In these cases, the relationship of the unit cell orientation with respect to the framework type is listed. This relationship is important when comparing the orientation of the channel direction and the viewing direction of ring drawings (which are both given for the axis orientation of the type material) with that of the framework drawing.

Framework density (FD)

The framework density is defined as the number of T-atoms per 1000 $Å^3$. The figures given refer to the type materials. For non-zeolitic framework structures, values of at least 20 to 21 T/1000 $Å^3$ are generally obtained, while for zeolites with fully crosslinked frameworks the observed values range from about 12.1 for structures with the largest pore volume to around 20.6. To date, FD's of less than 12 have only been encountered for the interrupted framework cloverite[13], and for hypothetical networks[14]. The FD is obviously related to the pore volume but does not reflect the size of the pore openings. For some more flexible zeolite structure types, the FD values can vary appreciably. In these cases (e.g., gismondine) values are given for the type material and for the framework in its most expanded state. The flexibility of a framework structure is, to some extent, revealed by the possible variation in the FD. FD values may also depend on chemical composition.

Channels

A shorthand notation has been adopted for the description of the channels in the various frameworks. Each system of equivalent channels has been characterized by

- the channel direction (relative to the axes of the type material structure),
- the number of T-atoms (in bold type) forming the rings controlling diffusion through the channels, and
- the crystallographic free diameters of the channels in Angstrom units.

The number of asterisks in the notation indicates whether the channel system is one-, two- or three-dimensional. In most cases, the smaller openings simply form windows (rather than channels)

connecting larger cavities. Interconnecting channel systems are separated by a double arrow (´). A vertical bar (|) means that there is no direct access from one channel system to the other. The examples from Table 2 have been selected to illustrate the use of these notations. Cancrinite is characterized by a 1-dimensional system of channels parallel to [001] or *c* with circular 12-ring apertures. In offretite, the main channels are similar but they are interconnected at right angles by a 2-dimensional system of 8-ring channels, and thus form a 3-dimensional channel system. The channel system in mordenite is essentially 2-dimensional with somewhat elliptical 12-ring apertures. The 8-ring limiting diffusion in the [001] direction is an example of a highly puckered aperture. Zeolite rho is an example of a framework type containing two non-interconnecting 3-dimensional channel systems which are displaced with respect to one another (<100> means there are channels parallel to all crystallographically equivalent axes of the cubic structure, i.e., along x, y and z.). In gismondine, the channels parallel to [100] together with those parallel to [010] give rise to a 3-dimensional channel system which can be pictured as an array of partially overlapping tubes.

Table 2: Examples illustrating the notation for the crystallographic characterization of the Channels

Cancrinite	[001] **12** 5.9 x 5.9*
Offretite	[001] **12** 6.7 x 6.8* ´ **^** [001] **8** 3.6 x 4.9**
Mordenite	[001] **12** 6.5 x 7.0* ´ {[010] **8** 3.4 x 4.8 ´ [001] **8** 2.6 x 5.7}*
Zeolite Rho	<100> **8** 3.6 x 3.6*** | <100> **8** 3.6 x 3.6***
Gismondine	{[100] **8** 3.1 x 4.5 ´ [010] **8** 2.8 x 4.8}***

Please note: The channel direction is given for the axis orientation of the *type material.* This orientation may be different from the orientation given in the framework drawing (see the cell relationship given under "crystal chemical data" for these cases).

A summary of the channel systems, ordered by decreasing number of T-atoms in the largest rings, is given in Table 3. The free diameter values (effective pore width) given in the channel description and on the ring drawings are based upon the atomic coordinates of the *type material* and an oxygen radius of 1.35Å. Both minimum and maximum values are given for noncircular apertures. In some instances, the corresponding interatomic distance vectors are only approximately coplanar, in other cases the plane of the ring is not normal to the direction of the channel. Close inspection of the framework and ring drawings should provide qualitative evidence of these factors. Some ring openings are defined by a very complex arrangement of oxygen atoms, so in these cases other short interatomic distances that are not listed may also be observed. It should be noted that crystallographic free diameters may depend upon the hydration state of the zeolite, particularly for the more flexible frameworks. It should also be borne in mind that effective free diameters can be affected by non-framework cations and may also be temperature dependent.

Table 3: Channel dimensions

20-, 18- &14-Ring Structures

-CLO	Cloverite	<100> **20** 4.0 x 13.2*** | <100> **8** 3.8 x 3.8***
VFI	VPI-5	[001] **18** 12.7 x 12.7*
AET	AlPO-8	[001] **14** 7.9 x 8.7*
CFI	CIT-5	[010] **14** 7.2 x 7.5*
DON	UTD-1F	[010] **14** 8.1 x 8.2*
OSO	OSB-1	[001] **14** 5.4 x 7.3* ´ **^** [001] **8** 2.8 x 3.3**

12-Ring Structures

AFI	AlPO-5	[001] **12** 7.3 x 7.3*
AFR	SAPO-40	[001] **12** 6.7 x 6.9* ´ [010] **8** 3.7 x 3.7*
AFS	MAPSO-46	[001] **12** 7.0 x 7.0* ´ **^** [001] **8** 4.0 x 4.0**
AFY	CoAPO-50	[001] **12** 6.1 x 6.1* ´ **^** [001] **8** 4.0 x 4.3**
ASV	ASU-7	[001] **12** 4.1x 4.1*
ATO	AlPO-31	[001] **12** 5.4 x 5.4*
ATS	MAPO-36	[001] **12** 6.5 x 7.5*
***BEA**	Beta	<100> **12** 6.6 x 6.7** ´ [001] **12** 5.6 x 5.6*
BOG	Boggsite	[100] **12** 7.0 x 7.0* ´ [010] **10** 5.5 x 5.8*
BPH	Beryllophosphate-H	[001] **12** 6.3 x 6.3* ´ **^** [001] **8** 2.7 x 3.5**
CAN	Cancrinite	[001] **12** 5.9 x 5.9*
CON	CIT-1	[001] **12** 6.4 x 7.0* ´ [100] **12** 7.0 x 5.9*
		´ [010] **10** 5.1 x 4.5*
CZP	Chiral Zincophosphate	[001] **12** 3.8 x 7.2*
DFO	DAF-1	{[001] **12** 7.3 x 7.3 ´ **^** [001] **8** 3.4 x 5.6}***
		´ {[001] **12** 6.2 x 6.2 ´ **^** [001] **10** 5.4 x 6.4}***
EMT	EMC-2	[001] **12** 7.3 x 7.3* ´ **^** [001] **12** 6.5 x 7.5**
FAU	Faujasite	<111> **12** 7.4 x 7.4***
GME	Gmelinite	[001] **12** 7.0 x 7.0* ´ **^** [001] **8** 3.6 x 3.9**
GON	GUS-1	[001] **12** 5.4 x 6.8*
IFR	ITQ-4	[001] **12** 6.2 x 7.2*
ISV	ITQ-7	<100> **12** 6.1 x 6.5** ´ [001] **12** 5.9 x 6.6*
LTL	Linde Type L	[001] **12** 7.1 x 7.1*
MAZ	Mazzite	[001] **12** 7.4 x 7.4* | [001] **8** 3.1 x 3.1***

12-Ring Structures (cont.)

MEI	ZSM-18	[001] **12** 6.9 x 6.9* ´ **^** [001] **7** 3.2 x 3.5**
MOR	Mordenite	[001] **12** 6.5 x 7.0* ´ {[010] **8** 3.4 x 4.8 ´ [001] **8** 2.6 x 5.7}*
MTW	ZSM-12	[010] **12** 5.6 x 6.0*
OFF	Offretite	[001] **12** 6.7 x 6.8* ´ **^** [001] **8** 3.6 x 4.9**
OSI	UiO-6	[001] **12** 5.2 x 6.0*
-RON	Roggianite	[001] **12** 4.3 x 4.3*
SAO	STA-1	<100>**12** 6.5 x 7.2** ´ [001] **12** 7.0 x 7.0*
SBE	UCSB-8Co	<100> **12** 7.2 x 7.4** ´ [001] **8** 4.0 x 4.0*
SBS	UCSB-6GaCo	[001] **12** 6.8 x 6.8* ´ **^** [001] **12** 6.9 x 7.0**
SBT	UCSB-10GaZn	[001] **12** 6.4 x 7.4 * ´ **^** [001] **12** 7.3 x 7.8**
SFE	SSZ-48	[010] **12** 5.4 x 7.6*
VET	VPI-8	[001] **12** 5.9 x 5.9*

10-Ring Structures

AEL	AlPO-11	[001] **10** 4.0 x 6.5*
AFO	AlPO-41	[001] **10** 4.3 x 7.0*
AHT	AlPO-H2	[001] **10** 3.3 x 6.8*
CGF	Co-Ga-Phosphate-5	{[100] **10** 2.5 x 9.2* + **8** 2.1 x 6.7*} ´ [001] **8** 2.4 x 4.8*
CGS	Co-Ga-Phosphate-6	{[001] **10** 3.5 x 8.1 ´ [100] **8** 2.5 x 4.6}***
DAC	Dachiardite	[010] **10** 3.4 x 5.3* ´ [001] **8** 3.7 x 4.8*
EPI	Epistilbite	[100] **10** 3.4 x 5.6* ´ [001] **8** 3.7 x 4.5*
EUO	EU-1	[100] **10** 4.1 x 5.4*
FER	Ferrierite	[001] **10** 4.2 x 5.4* ´ [010] **8** 3.5 x 4.8*
HEU	Heulandite	{[001] **10** 3.1 x 7.5* + **8** 3.6 x 4.6*} ´ [100] **8** 2.8 x 4.7*
LAU	Laumontite	[100] **10** 4.0 x 5.3*
MEL	ZSM-11	<100> **10** 5.3 x 5.4***
MFI	ZSM-5	{[100] **10** 5.1 x 5.5 ´ [010] **10** 5.3 x 5.6}***
MFS	ZSM-57	[100] **10** 5.1 x 5.4* ´ [010] **8** 3.3 x 4.8*
MTT	ZSM-23	[001] **10** 4.5 x 5.2*
MWW	MCM-22	**^** [001] **10** 4.0 x 5.5** | **^** [001] **10** 4.1 x 5.1**
NES	NU-87	[100] **10** 4.8 x 5.7**
-PAR	Partheite	[001] **10** 3.5 x 6.9*
SFF	SSZ-44	[001] **10** 5.4 x 5.7*
STF	SSZ-35	[001] **10** 5.4 x 5.7*

10-Ring Structures (cont.)

STI	Stilbite	[100] **10** 4.7 x 5.0* ´ [001] **8** 2.7 x 5.6*
TER	Terranovaite	[100] **10** 5.0 x 5.0* ´ [001] **10** 4.1 x 7.0*
TON	Theta-1	[001] **10** 4.6 x 5.7*
WEI	Weinebeneite	[001] **10** 3.1 x 5.4* ´ [100] **8** 3.3 x 5.0*
-WEN	Wenkite	<100> **10** 2.5 x 4.8** ´ [001] **8** 2.3 x 2.7*

9-Ring Structures

-CHI	Chiavennite	[001] **9** 3.9 x 4.3*
LOV	Lovdarite	[010] **9** 3.2 x 4.5* ´ [001] **9** 3.0 x 4.2*´ [100] **8** 3.6 x 3.7*
NAT	Natrolite	<100> **8** 2.6 x 3.9** ´ [001] **9** 2.5 x 4.1*
RSN	RUB-17	[100] **9** 3.3 x 4.4* ´ [001] **9** 3.1 x 4.3* ´ [010] **8** 3.4 x 4.1*
STT	SSZ-23	[101] **9** 3.7 x 5.3* ´ [001] **7** 2.4 x 3.5*
VSV	VPI-7	[01-1] **9** 3.3 x 4.3* ´ [011] **9** 2.9 x 4.2* ´ [011] **8** 2.1 x 2.7*

8-Ring Structures

ABW	Li-A	[001] **8** 3.4 x 3.8*
ACO	ACP-1	<100> **8** 2.8 x 3.5** ´ [001] **8** 3.5 x 3.5*
AEI	AlPO-18	{[100] **8** 3.8 x 3.8 ´ [110] **8** 3.8 x 3.8 ´ [001] **8** 3.8 x 3.8}***
AEN	AlPO-EN3	[100] **8** 3.1 x 4.3* ´ [010] **8** 2.7 x 5.0*
AFN	AlPO-14	[100] **8** 1.9 x 4.6* ´ [010] **8** 2.1 x 4.9* ´ [001] **8** 3.3 x 4.0*
AFT	AlPO-52	**^** [001] **8** 3.2 x 3.8***
AFX	SAPO-56	**^** [001] **8** 3.4 x 3.6***
ANA	Analcime	irregular distorted 8-rings
APC	AlPO-C	[001] **8** 3.4 x 3.7* ´ [100] **8** 2.0 x 4.7*
APD	AlPO-D	[010] **8** 2.3 x 6.0* ´ [201] **8** 1.3 x 5.8*
ATN	MAPO-39	[001] **8** 4.0 x 4.0*
ATT	AlPO-12-TAMU	[100] **8** 4.2 x 4.6* ´ [010] **8** 3.8 x 3.8*
ATV	AlPO-25	[001] **8** 3.0 x 4.9*
AWO	AlPO-21	[100] **8** 2.7 x 5.5*
AWW	AlPO-22	[001] **8** 3.9 x 3.9*
BIK	Bikitaite	[010] **8** 2.8 x 3.7*
BRE	Brewsterite	[100] **8** 2.3 x 5.0* ´ [001] **8** 2.8 x 4.1*

8-Ring Structures (cont.)

CAS Cesium Aluminosilicate [001] **8** 2.4 x 4.7*

CHA Chabazite **^** [001] **8** 3.8 x 3.8***

DDR Deca-dodecasil 3R **^** [001] **8** 3.6 x 4.4**

DFT DAF-2 [001] **8** 4.1 x 4.1* ´ [100] **8** 1.8 x 4.7* ´ [010] **8** 1.8 x 4.7*

EAB TMA-E **^** [001] **8** 3.7 x 5.1**

EDI Edingtonite <110> **8** 2.8 x 3.8** ´ [001] **8** 2.0 x 3.1*

ERI Erionite **^** [001] **8** 3.6 x 5.1***

ESV ERS-7 [010] **8** 3.5 x 4.7*

GIS Gismondine {[100] **8** 3.1 x 4.5 ´ [010] **8** 2.8 x 4.8}***

GOO Goosecreekite [100] **8** 2.8 x 4.0* ´ [010] **8** 2.7 x 4.1* ´ [001] **8** 2.9 x 4.7*

ITE ITQ-3 [010] **8** 3.8 x 4.3* ´ [001] **8** 2.7 x 5.8*

JBW NaJ [001] **8** 3.7 x 4.8*

KFI ZK-5 <100> **8** 3.9 x 3.9*** | <100> **8** 3.9 x 3.9***

LEV Levyne **^** [001] **8** 3.6 x 4.8**

LTA Linde Type A <100> **8** 4.1 x 4.1***

MER Merlinoite [100] **8** 3.1 x 3.5* ´ [010] **8** 2.7 x 3.6*
´ [001] {**8** 3.4 x 5.1* + **8** 3.3 x 3.3*}

MON Montesommaite [100] **8** 3.2 x 4.4* ´ [001] **8** 3.6 x 3.6*

MTF MCM-35 [001] **8** 3.6 x 3.9*

PAU Paulingite <100> **8** 3.6x3.6*** | <100> **8** 3.6 x 3.6***

PHI Phillipsite [100] **8** 3.8 x 3.8* ´ [010] **8** 3.0 x 4.3* ´ [001] **8** 3.2 x 3.3*

RHO Rho <100> **8** 3.6 x 3.6*** | <100> **8** 3.6 x 3.6***

RTE RUB-3 [001] **8** 3.7 x 4.4*

RTH RUB-13 [100] **8** 3.8 x 4.1* ´ [001] **8** 2.5 x 5.6*

SAS STA-6 [001] **8** 4.2 x 4.2*

SAT STA-2 **^** [001] 3.0 x 5.5***

SAV Mg-STA-7 <100> **8** 3.8 x 3.8** ´ [001] **8** 3.9 x 3.9*

THO Thomsonite [100] **8** 2.3 x 3.9* ´ [010] **8** 2.2 x 4.0* ´ [001] **8** 2.2 x 3.0*

TSC Tschörtnerite <100> **8** 4.2 x 4.2*** ´ <110> **8** 3.1 x 5.6***

VNI VPI-9 {<110> **8** 3.1 x 4.0 ´ [001] **8** 3.5 x .3.6}***

YUG Yugawaralite [100] **8** 2.8 x 3.6* ´ [001] **8** 3.1 x 5.0*

ZON ZAPO-M1 [100] **8** 2.5 x 5.1* ´ [010] **8** 3.7 x 4.4*

Stability

In some cases, the type material is not stable to heating and/or removal of the template. This has been indicated where the information was available.

Stereographic figures

Stereographic drawings of the framework and of the limiting channel windows are presented for all framework types. These drawings have been generated using the program CrystalMaker[(15)]. Although the depth fading helps in viewing the drawings, the use of a stereo viewer is recommended (these can be obtained from any electron microscopy supply house).

For the framework drawings, the coordinates of the idealized, highest symmetry structures were used. Only the positions of the T-atoms are shown and the T-O-T bridges are represented by straight lines. This idealization makes it easier to visualize the topology and the basic features of zeolite-like framework structures, which are often relatively complex. The unit cell has been outlined wherever possible.

In the ring drawings, all atoms are shown. Their positions are based on the crystal structure of the type material, and therefore the ring dimensions and the viewing direction are also those of the type material. As explained in the crystal chemical data section, for a few type materials, the orientation of the crystallographic axes is different from that given for the framework type. In these cases, the relationship given in the "crystal chemical data" section must be applied when comparing the viewing direction of the ring drawings with that of the framework drawing.

Supplementary Information

Topological densities

The coordination sequences (CS) can be used to calculate a topological density (TD). As might be expected, the CS is a periodic function. This has been established for all observed framework topologies by Grosse–Kunstleve, Brunner and Sloane[(16)]. They showed that the CS of any T–atom can be described exactly by a set of p quadratic equations

$N_k = a_i k^2 + b_i k + c_i$ for $k = i + np$, $n = 0,1,2,...$ and $i = 1,2,3, ... p$

For example, the CS of **ABW** is exactly described by a set of three quadratic equations (p=3), namely

$N_k = 19/9\ k2 + 1/9\ k + 16/9$ for $k = 1 + 3n$, $n=0,1,2,...$

$N_k = 19/9\ k2 - 1/9\ k + 16/9$ for $k = 2 + 3n$, $n=0,1,2,...$

$N_k = 19/9\ k2 - 0\ k + 2$ for $k = 3 + 3n$, $n=0,1,2,...$

The number of equations p necessary to calculate all members of a particular coordination sequence varies from p=1 for **SOD** and p=42 for **FAU** to p=140,900,760 for **EUO**.

With growing index k (the shell number of the CS), the linear and constant coefficients, b_i and c_i, respectively, become less and less important. Therefore we can define the exact topological density TD as the mean of all a_i divided by the dimensionality of the topology (i.e. 3 for zeolites)

$$TD = \frac{< a_i >}{3} = \frac{1}{3\,p}\sum_{i=1}^{p} a_i$$

This TD is the same for all T atoms in a given structure. The values are listed for all structure types together with the TD_{10}, which was listed in the previous editions of the ATLAS, in Appendix C. There is a simple relationship between TD and TD_{10}: $TD_{10} \sim TD * 1155$. Since TD_{10} is an approximation, i.e. it is 'arbitarily' terminated at N_{10}, the values obtained by this formula deviate by 11% for **–CLO** and 5% for **FAU** but the differences are generally below 3%. It seem that for very open structures, 10 steps are not sufficient for a satifactory convergence. The correlation factor between the exact topological density TD and the framework density FD is 0.82 .

Origin of 3-letter codes and type material names

The derivation of the 3-letter codes for the zeolite minerals is fairly obvious, because the code generally consists of the first 3 letters of the mineral name. For the synthetic materials this is sometimes more obscure. One reason for this is that numbers are frequently included to distinguish different products from a particular lab, and these numbers cannot be transferred directly to the framework code. To help the reader better understand the origin of the codes, a table that includes all framework type codes derived from synthetic type materials is given in Appendix D. In this table, the letters taken for the code are written in bold. Also, an attempt has been made to decipher the origin of the mnemonic sometimes used in the designations of these materials.

Isotypic material index

All materials are listed in alphabetical order in this index. To make the index as informative as possible, all reported materials and designations have been included in this section, provided the framework type assignment appears to be reasonably well established. Even a number of occasionally used, but discredited, names of mineral species have been included for the same reason. A full list of obsolete and discredited zeolite mineral names can be found in a report of the subcommittee on zeolites of the International Mineralogical Association[17]. Moreover, the inclusion of a synthetic material's designation in this index must not be interpreted to mean that the designation has been formally recognized or generally accepted. References are to be found on the respective framework type data sheets.

References

(1) W.M. Meier and D.H. Olson, *Adv. Chem. Ser*. **101**, 155 (1970).

(2) L.B. McCusker, F. Liebau and G. Engelhardt, *Pure Appl. Chem*. **73** (2001), in press

(3) G.O. Brunner and W.M. Meier, *Nature* **337**, 146 (1989)

(4) R.M. Barrer, "Chemical Nomenclature and Formulation of Compositions of Synthetic and Natural Zeolites", *Pure Appl. Chem.* **51**, 1091 (1979).

(5) Ch. Baerlocher, A. Hepp. and W.M Meier, "DLS-76, a program for the simulation of crystal structures by geometric refinement". (1978). Lab. f. Kristallographie, ETH, Zürich.

(6) G.O. Brunner and F. Laves, Wiss. Z. Techn. Univers. Dresden **20**, 387 (1971) H.2.

(7) W.M,. Meier and H.J. Moeck, *J. Solid State Chem.* **27**, 349 (1979).

(8) M. O'Keeffe and S.T. Hyde, *Zeolites* **19**, 370 (1997)

(9) M. Sato, Proc. 6th IZC, Reno (Butterworth, 1984) p. 851.

(10) G.O. Brunner, *Zeolites* **13**, 88 (1993)

(11) J.V. Smith: Geometrical and Structural Crystallography (Wiley, 1982) p. 328.

(12) Zeolite Structure Codes ABW to CZP. Subvolume B in Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, New Series, Group IV: Physical Chemistry, Volume 14, Microporous and other Framework Materials with Zeolite-Type Structures, eds. W.H. Baur, R.X. Fischer, VIII & 459 pp., Springer, Berlin, 2000.

(13) M. Estermann, L.B. McCusker, Ch. Baerlocher, A. Merrouche and H. Kessler, *Nature* **352**, 320 (1991)

(14) W.M. Meier, Proc. 7th IZC Tokyo (Kodansha-Elsevier, 1986) p. 13.

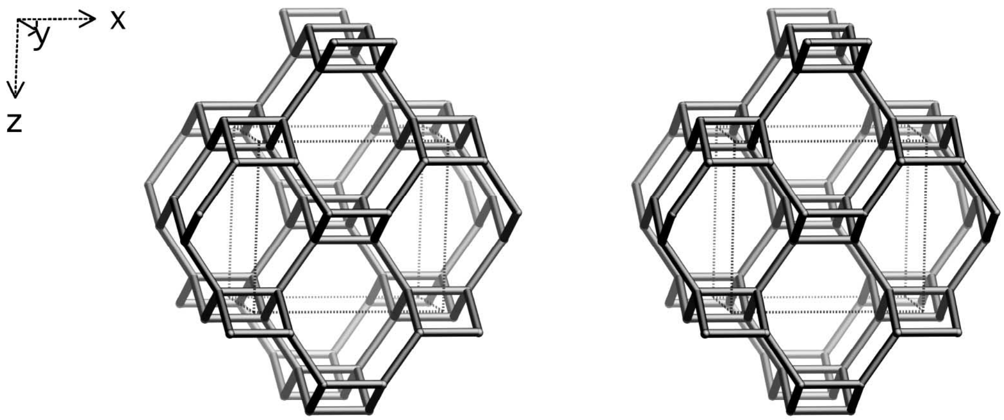
(15) CrystalMaker, a Crystal Structure Program for MacOS Computers. CrystalMaker Software, P.O. Box 183, Bicester, Oxfordshire, OX6 7BS, UK (http://www.crystalmaker.co.uk)

(16) R.W. Grosse-Kunstleve, G.O. Brunner and N.J.A. Sloane, *Acta Crystallogr.* **A52**, 879-889 (1996)

(17) D.S. Coombs, A. Alberti, T. Armbruster, G. Artioli, C. Colella, E. Galli, J.D. Grice, F. Liebau, J.A. Mandarino, H. Minato, E.H. Nickel, E. Passaglia, D.R. Peacor, S. Quartieri, R. Rinaldi, M. Ross, R.A. Sheppard, E. Tillmanns, G. Vezzalini, "Recommended nomenclature for zeolite minerals: Report of the subcommittee on zeolites of the international mineralogical association, commission on new minerals and mineral names", *Can. Mineral.* **35**, 1571 (1997), or, *Mineral. Mag*. **64**, 533 (1998), or, *Eur. J. Mineral*. **10**, 1037 (1998).

FRAMEWORK TYPE DATA SHEETS

(arranged by 3-letter code in alphabetical order)



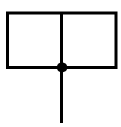
framework viewed along [010]

Idealized cell constants: orthorhombic, Imma, a = 9.9Å, b = 5.3Å, c = 8.8Å

Coordination sequences and vertex symbols: T_1 (8, m) 4 10 21 36 54 78 106 136 173 214 $4 \cdot 6 \cdot 4 \cdot 6 \cdot 6 \cdot 8_2$

Secondary building units: 8 or 6 or 4

Loop configuration of T-Atoms:



T_1

Isotypic framework structures:

*Li-A (Barrer and White)[1-3]
[Be-As-O**]-ABW**[4,5]
[Be-P-O**]-ABW**[4,6]
[Ga-Si-O**]-ABW**[7]
[Zn-As-O**]-ABW**[4]
[Zn-P-O**]-ABW**[4]
|Cs-**|[**Mg-P-O**]-ABW**[8]
|Cs-**|[**Al-Si-O**]-ABW**[9,10]
|Cs-**|[**Al-Ti-O**]-ABW**[11]
|Li-**|[**Al-Si-O**]-ABW**[12]
|Li-**|[**Zn-P-O**]-ABW**[13]
|Li-**|[**Al-Ge-O**]-ABW**[14]
|Na-**|[**Co-P-O**]-ABW**[15]
|Rb-**|[**Co-P-O**]-ABW**[8]
|Rb-**|[**Al-Si-O**]-ABW**[9,10]
|Tl-**|[**Al-Si-O**]-ABW**[16]

References:

(1) Barrer, R.M. and White, E.A.D. *J. Chem. Soc.*, 1267-1278 (1951)
(2) Kerr, I.S. *Z. Kristallogr.*, **139**, 186-195 (1974)
(3) Krogh Andersen, E. and Ploug-Sørensen, G. *Z. Kristallogr.*, **176**, 67-73 (1986)
(4) Gier, T.E. and Stucky, G.D. *Nature*, **349**, 508-510 (1991)
(5) Harrison, W.T.A., Gier, T.E. and Stucky, G.D. *Acta Crystallogr.*, **C51**, 181-183 (1995)
(6) Robl, C. and Gobner, V. *J. Chem. Soc., Dalton Trans.*, 1911-1912 (1993)
(7) Newsam, J.M. *J. Phys. Chem.*, **92**, 445-452 (1988)
(8) Rakotomahanina Ralaisoa, E.L. *Ph.D. Thesis, Univ. Grenoble*, (1972)
(9) Klaska, R. and Jarchow, O. *Naturwiss.*, **60**, 299 (1973)

Crystal chemical data: |Li^+_4 $(H_2O)_4$| [Al_4Si_4 O_{16}]-**ABW**
orthorhombic, Pna2_1, a = 10.31Å, b = 8.18Å, c = 5.00Å [(2)]
(Relationship to unit cell of Framework Type: a' = a, b' = c, c' = b)

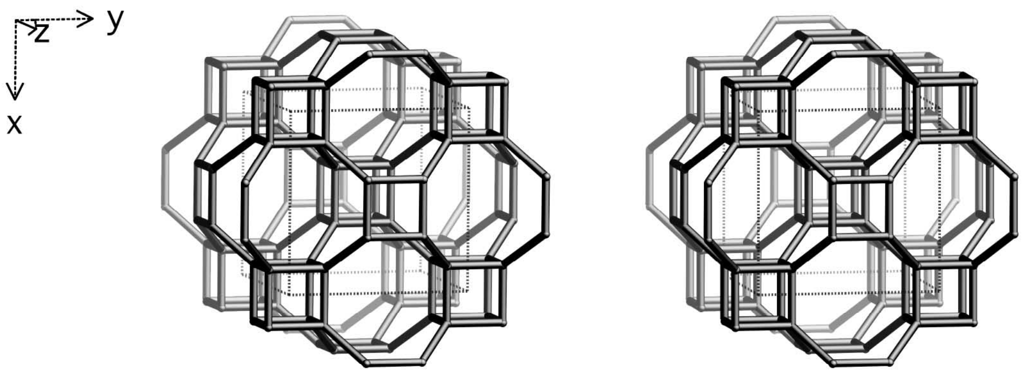
Framework density: 19 T/1000Å^3

Channels: [001] **8** 3.4 x 3.8*



8-ring viewed along [001]

References (cont.):
(10) Klaska, R. and Jarchow, O. *Z. Kristallogr.*, **142**, 225-238 (1975)
(11) Gatehouse, B.M. *Acta Crystallogr.*, **C45**, 1674-1677 (1989)
(12) Ghobarkar, H. *Cryst. Res. Technol.*, **27**, 1071-1075 (1992)
(13) Harrison, W.T.A., Gier, T.E., Nicol, J.M. and Stucky, G.D. *J. Solid State Chem.*, **114**, 249-257 (1995)
(14) Tripathi, A., Kim, S.J., Johnson, G.M. and Parise, J.B. *Microporous and Mesoporous Materials*, **34**, 273-279 (2000)
(15) Chippindale, A.M., Cowley, A.R., Chen, J.S., Gao, Q. and Xu, R. *Acta Crystallogr.*, **C55**, 845-847 (1999)
(16) Krogh Andersen, I.G., Krogh Andersen, E., Norby, P., Colella, C. and Degennaro, M. *Zeolites*, **11**, 149-154 (1991)



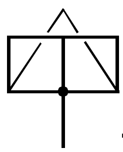
framework viewed along [001]

Idealized cell constants: cubic, Im$\bar{3}$m, a = 9.9Å

Coordination sequences and vertex symbols: T_1 (16, 3m) 4 9 19 35 52 72 100 131 163 201 $4 \cdot 8_2 \cdot 4 \cdot 8_2 \cdot 4 \cdot 8_2$

Secondary building units: 4-4 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *ACP-1[1]

References:

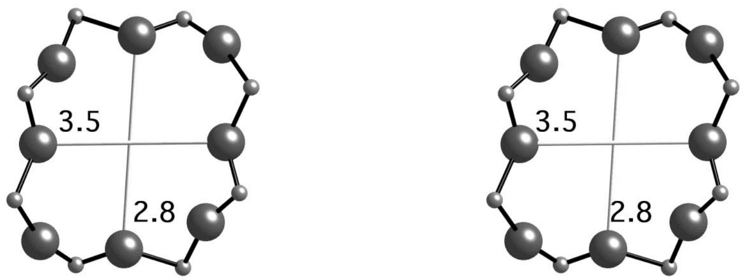
(1) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)

ACP-1 Type Material ACO

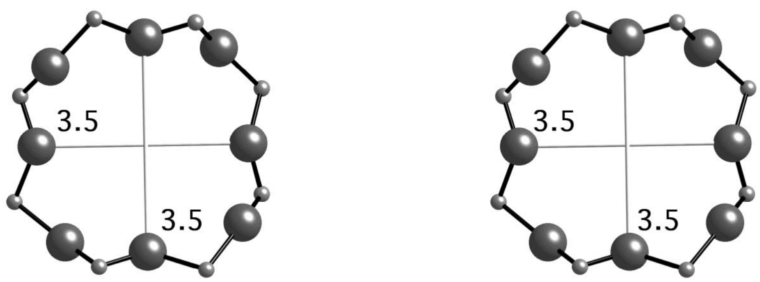
Crystal chemical data: **|**$(C_2H_{10}N_2^{2+})_4\ (H_2O)_2$**| [**$Al_{0.88}Co_{7.12}P_8\ O_{32}$**]-ACO**
$C_2H_8N_2$ = ethylenediamine
tetragonal, $I\bar{4}2m$, a = 10.240Å, c = 9.652Å [1]

Framework density: 15.8 T/1000Å^3

Channels: <100> **8** 2.8 x 3.5** ↔ [001] **8** 3.5 x 3.5*

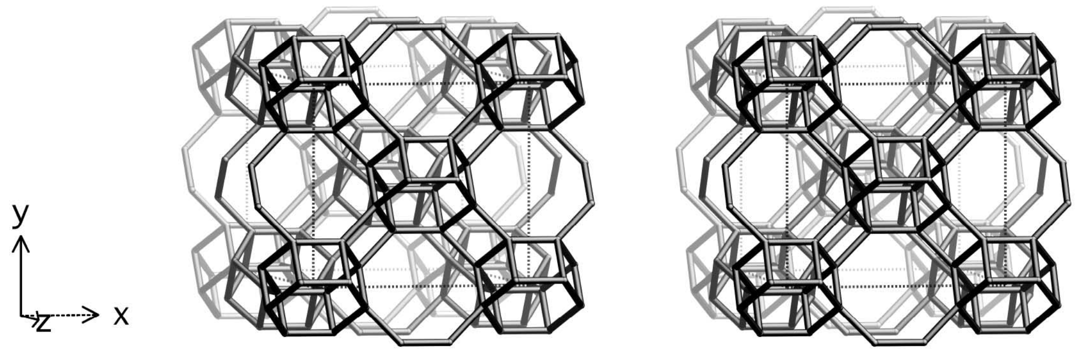


8-ring viewed along <100>



8-ring viewed along [001]

AEI Framework Type Cmcm



framework viewed along [001]

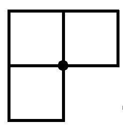
Idealized cell constants: orthorhombic, Cmcm, a = 13.7Å, b = 12.6Å, c = 18.5Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	17	29	45	64	85	111	143	177	4·4·4·8·6·8
T_2 (16, 1)	4	9	17	29	45	65	88	113	143	178	4·4·4·8·6·8
T_3 (16, 1)	4	9	17	29	45	65	87	113	143	176	4·4·4·8·6·8

Secondary building units: 6-6 or 4-2 or 6 or 4

Loop configuration of T-Atoms:



T_{1-3}

Isotypic framework structures: *AlPO-18[1]

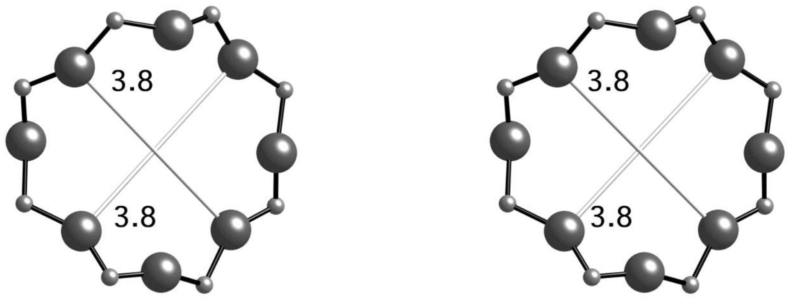
References:

(1) Simmen, A., McCusker, L.B., Baerlocher, Ch. and Meier, W.M. *Zeolites*, **11**, 654-661 (1991)

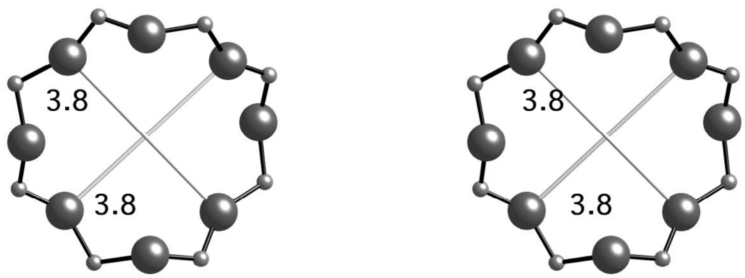
Crystal chemical data: **[**$Al_{24}P_{24}\ O_{96}$**]-AEI**
monoclinic, C12/c1
a = 13.711Å, b = 12.732Å, c = 18.571Å, β = 90.01° [(1)]

Framework density: 14.8 T/1000Å^3

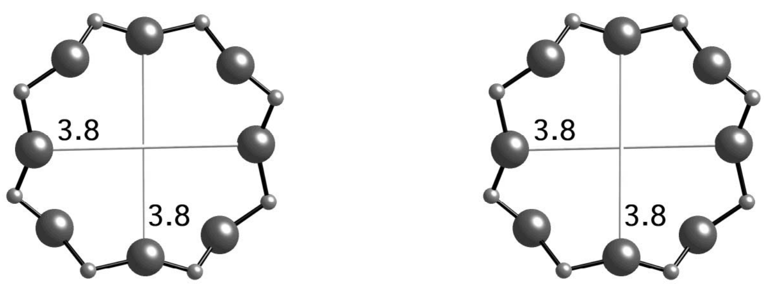
Channels: {[100] **8** 3.8 x 3.8 ↔ [110] **8** 3.8 x 3.8 ↔ [001] **8** 3.8 x 3.8}***



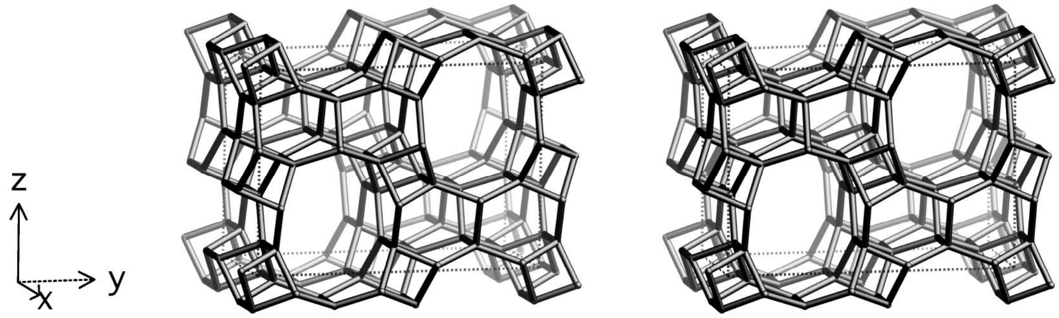
8-ring viewed along [100]



8-ring viewed along [110]



8-ring viewed along [001]



framework viewed along [100]

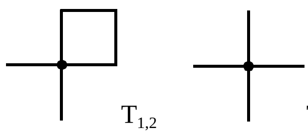
Idealized cell constants: orthorhombic, Imma, a = 8.3Å, b = 18.7Å, c = 13.4Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	21	37	59	85	114	150	189	232	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_2 (16, 1)	4	11	22	38	58	85	115	148	188	234	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_3 (8, m)	4	12	24	40	59	84	115	150	186	230	$6 \cdot 6_2 \cdot 6_2 \cdot 6_2 \cdot 6_2 \cdot 6_2$

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures:
*AlPO-11[1,2]
MnAPO-11[3]
SAPO-11 plus numerous compositional variants[4,5]

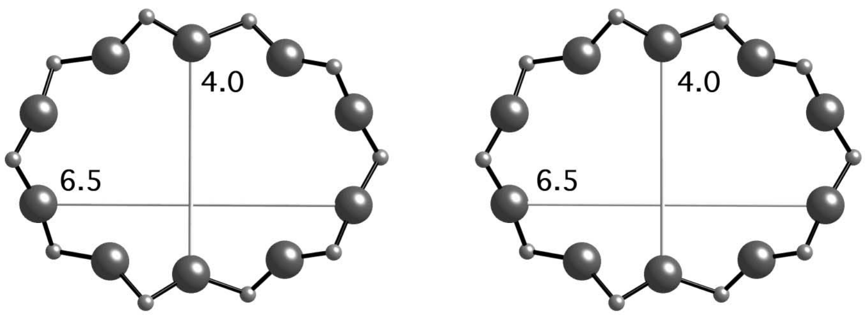
References:

(1) Bennett, J.M., Richardson Jr., J.W., Pluth, J.J. and Smith, J.V. *Zeolites*, **7**, 160-162 (1987)
(2) Richardson Jr., J.W., Pluth, J.J. and Smith, J.V. *Acta Crystallogr.*, **B44**, 367-373 (1988)
(3) Pluth, J.J., Smith, J.V. and Richardson Jr., J.W. *J. Phys. Chem.*, **92**, 2734-2738 (1988)
(4) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)
(5) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo

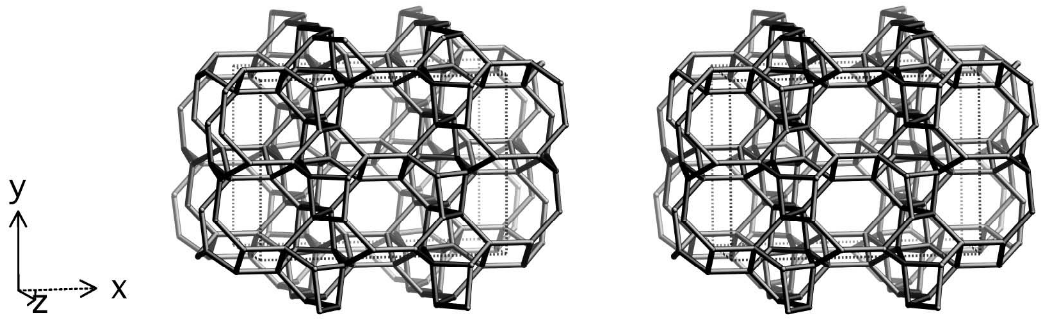
Crystal chemical data: **[**$Al_{20}P_{20}\ O_{80}$**]-AEL**
orthorhombic, Ibm2, a = 13.534Å, b = 18.482Å, c = 8.370Å (2)
(Relationship to unit cell of Framework Type: a' = c, b' = b, c' = a)

Framework density: 19.1 T/1000$Å^3$

Channels: [001] **10** 4.0 x 6.5*



10-ring viewed along [001]



framework viewed along [001]

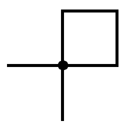
Idealized cell constants: orthorhombic, Cmca, a = 18.5Å, b = 13.4Å, c = 9.6Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	24	41	60	86	123	162	199	248	$4 \cdot 6_3 \cdot 6_2 \cdot 8_2 \cdot 6_3 \cdot 8$
T_2 (16, 1)	4	11	22	39	64	90	119	155	201	250	$4 \cdot 6 \cdot 6 \cdot 6_2 \cdot 6_2 \cdot 6_4$
T_3 (16, 1)	4	11	22	38	63	90	116	155	204	250	$4 \cdot 6_3 \cdot 6_2 \cdot 6_3 \cdot 6_2 \cdot 8$

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



T_{1-3}

Isotypic framework structures:

*AlPO-EN3[1]
[Ga-P-O**]-AEN**[2]
AlPO-53(A)[3]
AlPO-53(B)[3]
CFSAPO-1A[4]
JDF-2[5]
MSC-1[6]
UiO-12-500[7]
UiO-12-as[7]

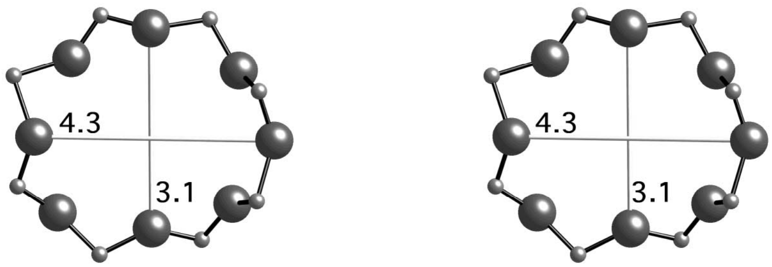
References:

(1) Parise, J.B. *Stud. Surf. Sci. Catal.*, **24**, 271-278 (1985)
(2) Glasser, F.P., Howie, R.A. and Kan, Q.B. *Acta Crystallogr.*, **C50**, 848-850 (1994)
(3) Kirchner, R.M., Grosse-Kunstleve, R.W., Pluth, J.J., Wilson, S.T., Broach, R.W. and Smith, J.V. *Microporous and Mesoporous Materials*, **39**, 319-332 (2000)
(4) He, H. and Long, Y. *J. Incl. Phenom.*, **5**, 591-599 (1987)
(5) Chippindale, A.M., Powell, A.V., Jones, R.H., Thomas, J.M., Cheetham, A.K., Huo, Q.S. and Xu, R.R. *Acta Crystallogr.*, **C50**, 1537-1540 (1994)
(6) Simmen, A. *Ph.D. Thesis*, *ETH, Zürich, Switzerland*, (1992)
(7) Kongshaug, K.O., Fjellvåg, H., Klewe, B. and Lillerud, K.P. *Microporous and Mesoporous Materials*, **39**, 333-339 (2000)

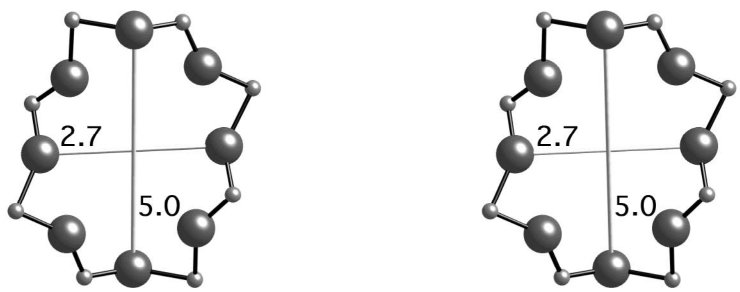
Crystal chemical data: **|**$(C_2H_8N_2)_4\ (H_2O)_{16}$**|** **[**$Al_{24}P_{24}\ O_{96}$**]-AEN**
$C_2H_8N_2$ = ethylenediamine
orthorhombic, $P2_12_12_1$, a = 10.292 Å, b = 13.636Å, c = 17.344 Å [1]
(Relationship to unit cell of Framework Type: a' = c, b' = b, c' = a)

Framework density: 19.7 T/1000Å^3

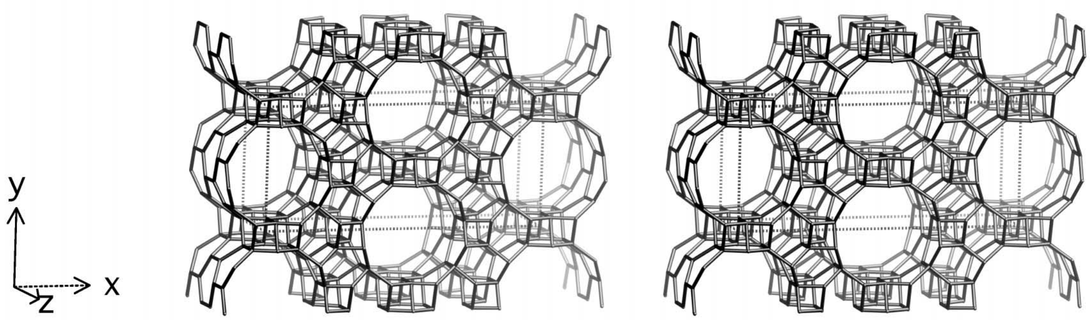
Channels: [100] **8** 3.1 x 4.3* ↔ [010] **8** 2.7 x 5.0*



8-ring viewed along [100]



8-ring viewed along [010]



framework viewed along [001]

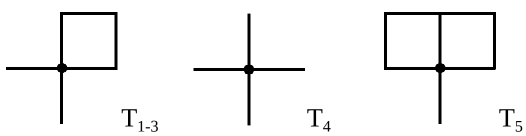
Idealized cell constants: orthorhombic, Cmcm, a = 32.8Å, b = 14.4Å, c = 8.4Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	21	35	53	78	108	140	172	208	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_2 (16, 1)	4	11	21	35	52	74	102	136	172	212	$4 \cdot 6_2 \cdot 6_2 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_3 (16, 1)	4	11	22	38	55	74	98	132	173	216	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_4 (16, 1)	4	12	23	36	52	75	103	135	172	215	$6 \cdot 6_2 \cdot 6_2 \cdot 6_2 \cdot 6_2 \cdot 6_2$
T_5 (8, m)	4	10	18	32	52	76	105	140	171	202	$4 \cdot 6_3 \cdot 4 \cdot 6_3 \cdot 6 \cdot 6_4$

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-8[1,2]
MCM-37[3]

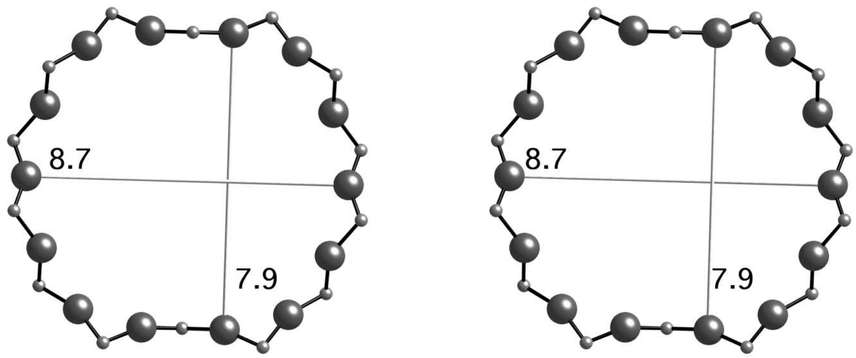
References:

(1) Dessau, R.M., Schlenker, J.L. and Higgins, J.B. *Zeolites*, **10**, 522-524 (1990)
(2) Richardson Jr., J.W. and Vogt, E.T.C. *Zeolites*, **12**, 13-19 (1992)
(3) Chu, C.T.W., Schlenker, J.L., Lutner, J.D. and Chang, C.D. *U.S. Patent 5,091,073* (1992)

Crystal chemical data: **[**$Al_{36}P_{36}O_{144}$**]-AET**
orthorhombic, $Cmc2_1$, a = 33.29Å, b = 14.76Å, c = 8.257Å [1]

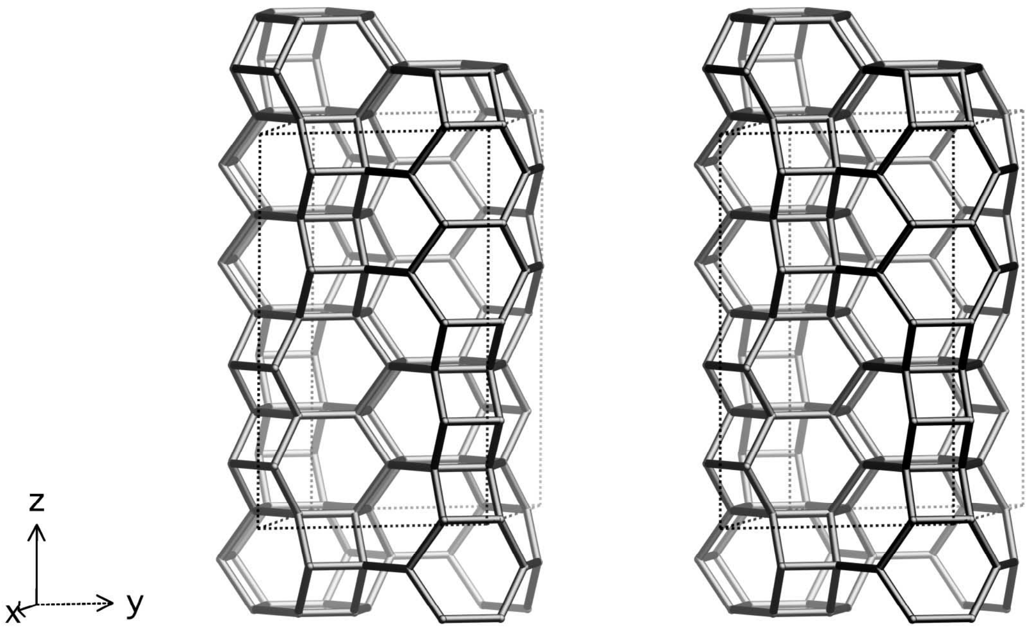
Framework density: 17.7 T/1000Å^3

Channels: [001] **14** 7.9 x 8.7*



14-ring viewed along [001]

AFG Framework Type $P6_3/mmc$



framework viewed normal to [001]

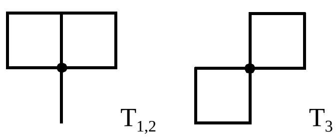
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 12.5Å, c = 20.8Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	10	20	34	53	76	103	135	170	208	4·6·4·6·6·6
T_2 (12, m)	4	10	20	34	54	78	104	134	168	210	4·6·4·6·6·6
T_3 (12, 2)	4	10	20	34	54	78	104	134	168	210	4·4·6·6·6·6

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



Framework description: ABABACAC sequence of 6-rings

Isotypic framework structures: *Afghanite[1-4]

References:

(1) Bariand, P., Cesbron, F. and Giraud, R. *Bull. Soc. fr. Minéral. Cristallogr.*, **91**, 34-42 (1968)

(2) Merlino, S. and Mellini, M. *Zeolite 1976, Program and Abstracts, Tucson*, (1976)

(3) Pobedimskaya, E.A., Rastsvetaeva, R.k., Terenteva, L.E. and Saposhnikov, A.N. *Dokl. Akad. Nauk SSSR*, **320**, 882-886 (1991)

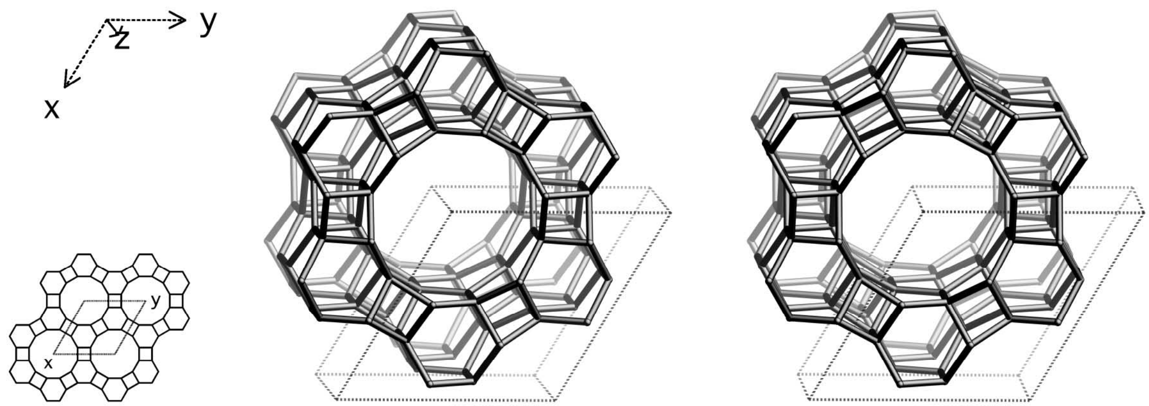
(4) Ballirano, P., Merlino, S., Bonaccorsi, E. and Maras, A. *Eur. J. Mineral.*, **9**, 21-31 (1997)

Crystal chemical data: **|**$Ca^{2+}_{9.8}$ Na^{+}_{22} Cl^{-}_{2} $SO_4^{2-}{}_{5.3}$ CO_3^{2-} $(H_2O)_4$**|** **[**$Al_{24}Si_{24}O_{96}$**]-AFG**
hexagonal , $P6_3mc$, a = 12.761Å, c = 21.416Å (3)

Framework density: 15.9 T/1000Å^3

Channels: apertures formed by 6-rings only

AFI Framework Type P6/mcc



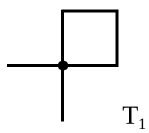
framework viewed along [001] (bottom left: projection down [001])

Idealized cell constants: hexagonal, P6/mcc, a = 13.8Å, c = 8.6Å

Coordination sequences and vertex symbols: T_1 (24, 1) 4 11 21 35 53 77 105 137 172 212 $4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*AlPO-5[1]
CoAPO-5[2]
CrAPO-5[3]
SAPO-5 and numerous compositional variants[4,5]
SSZ-24[6]
TPAF AlPO-5[7]

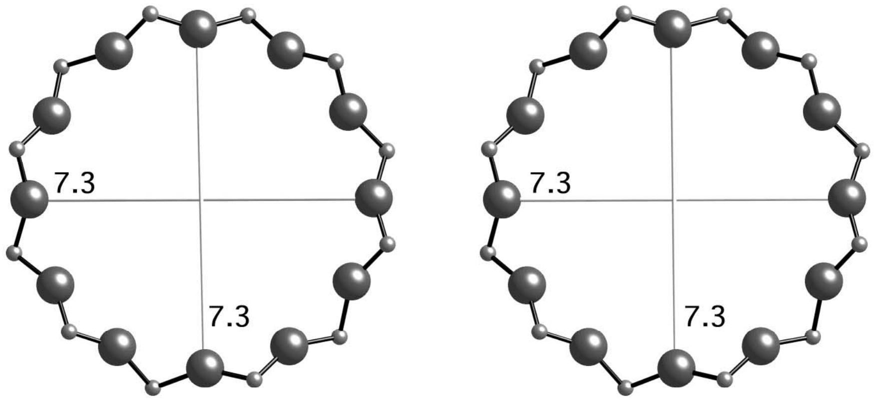
References:

(1) Bennett, J.M., Cohen, J.P., Flanigen, E.M., Pluth, J.J. and Smith, J.V. *ACS Sym. Ser.*, **218**, 109-118 (1983)
(2) Chao, K.J., Sheu, S.P. and Sheu, H.S. *J. Chem. Soc., Faraday Trans.*, **88**, 2949-2954 (1992)
(3) Radaev, S., Joswig, W. and Baur, W.H. *J. Mater. Chem.*, **6**, 1413-1418 (1996)
(4) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)
(5) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo
(6) Bialek, R., Meier, W.M., Davis, M. and Annen, M.J. *Zeolites*, **11**, 438-442 (1991)
(7) Qiu, S., Pang, W., Kessler, H. and Guth, J.L. *Zeolites*, **9**, 440-444 (1989)

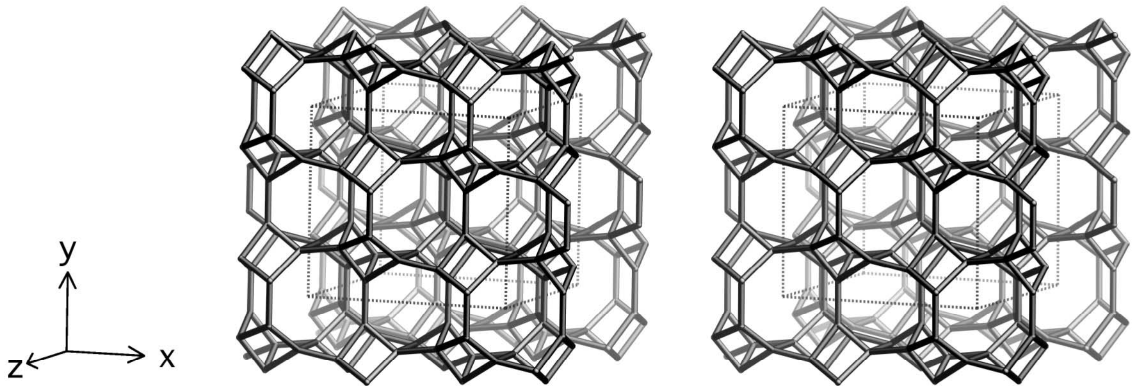
Crystal chemical data: **|**($C_{12}H_{28}N^+$) (OH^-) ($H_2O)_x$ **|[**$Al_{12}P_{12}$ O_{48}**]-AFI**
$C_{12}H_{28}N^+$ = tetrapropylammonium
hexagonal, P6cc, a = 13.726Å, c = 8.484Å (1)

Framework density: 17.3 T/1000Å^3

Channels: [001] **12** 7.3 x 7.3*



12-ring viewed along [001]



framework viewed normal to [010]

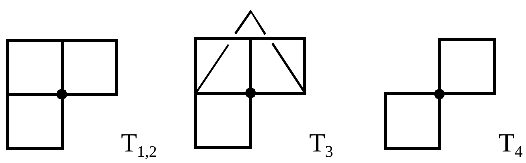
Idealized cell constants: monoclinic, C12/m1, a = 14.0Å, b = 13.5Å, c = 10.2Å, β = 107.2°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	19	33	51	76	98	123	162	203	$4\cdot4\cdot4\cdot8_2\cdot6\cdot8_4$
T_2 (8, 1)	4	9	18	31	49	72	99	130	160	198	$4\cdot4\cdot4\cdot8_2\cdot6\cdot6_2$
T_3 (8, 1)	4	9	17	30	49	75	102	125	157	202	$4\cdot6\cdot4\cdot8\cdot4\cdot8_7$
T_4 (8, 1)	4	10	21	35	50	71	100	132	164	198	$4\cdot4\cdot6\cdot8\cdot8\cdot8_2$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-14[1]
GaPO-14[2]

References:

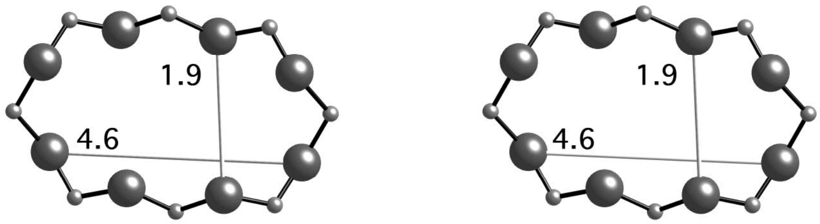
(1) Broach, R.W., Wilson, S.T. and Kirchner, R.M. In *Proc. 12th Int. Zeolite Conf.*, (eds. M.M.J. Treacy, B.K. Marcus, M.E. Bisher and J.B. Higgins), pp. 1715-1722 (1999), MRS, Warrendale, PA
(2) Parise, J.B. *Acta Crystallogr.*, **C42**, 670-673 (1986)

AlPO-14 **Type Material** **AFN**

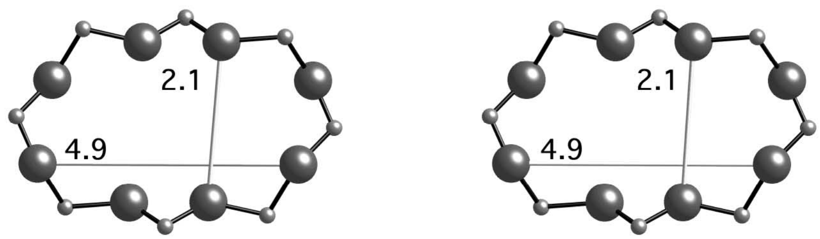
Crystal chemical data: **[**$Al_8P_8\ O_{32}$**]-AFN**
triclinic, $P\bar{1}$, a = 9.704Å, b = 9.736Å, c = 10.202Å
$\alpha = 77.81°$, $\beta = 77.50°$, $\gamma = 87.69°$ (1)

Framework density: 17.4 T/1000Å^3

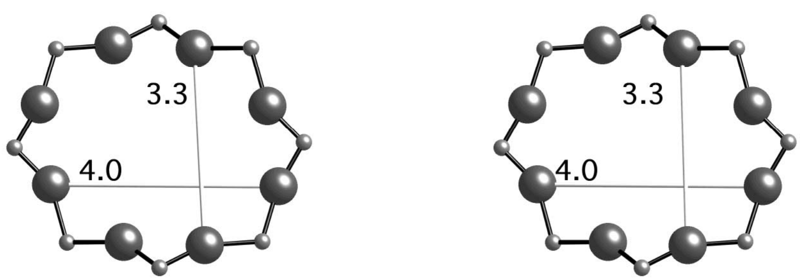
Channels: [100] **8** 1.9 x 4.6* ↔ [010] **8** 2.1 x 4.9* ↔ [001] **8** 3.3 x 4.0*



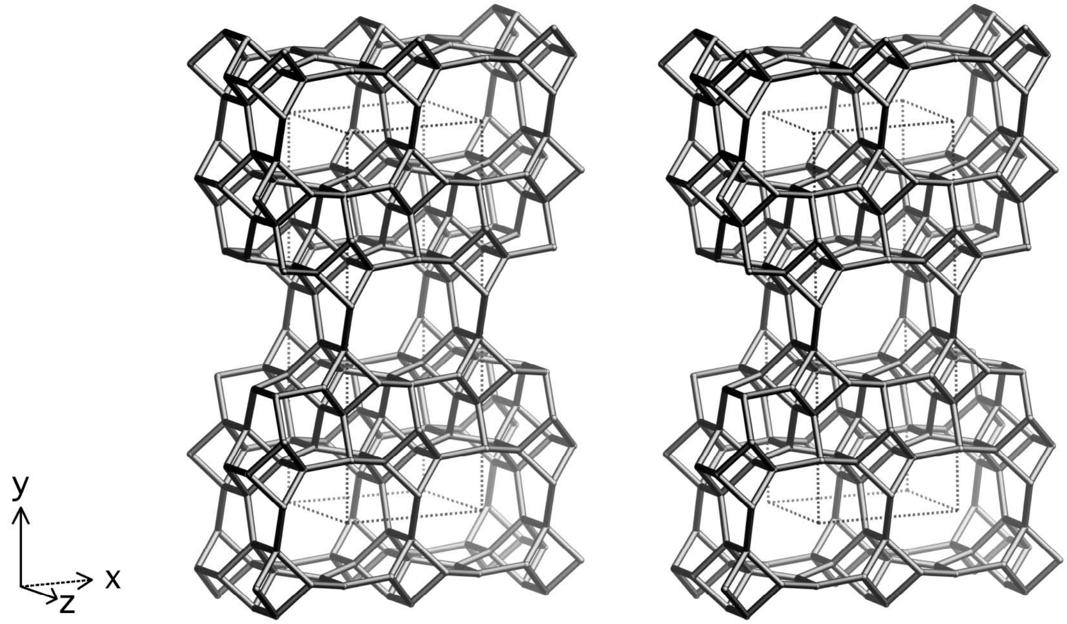
8-ring viewed along [100]



8-ring viewed along [010]



8-ring viewed along [001]



framework viewed along [001]

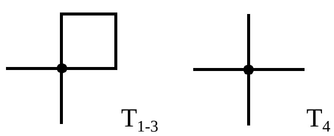
Idealized cell constants: orthorhombic, Cmcm, a = 9.8Å, b = 25.6Å, c = 8.3Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	22	38	58	85	115	149	190	235	$4\cdot6_2\cdot6\cdot6_3\cdot6_2\cdot6_3$
T_2 (8, m)	4	11	22	41	65	88	111	145	186	231	$4\cdot6_2\cdot6\cdot6_3\cdot6\cdot6_3$
T_3 (8, m)	4	11	21	36	56	82	115	156	195	231	$4\cdot6_2\cdot6_2\cdot6_3\cdot6_2\cdot6_3$
T_4 (8, m)	4	12	23	37	55	82	118	155	189	232	$6\cdot6_2\cdot6_2\cdot6_2\cdot6_2\cdot6_2$

Secondary building units: 2-6-2 or 4-1

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-41[1]

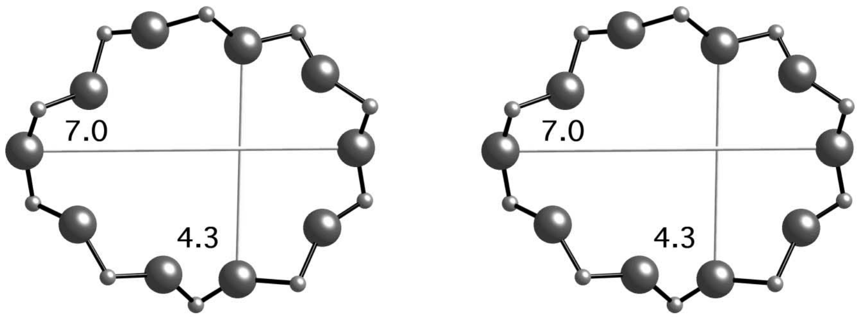
References:

(1) Kirchner, R.M. and Bennett, J.M. *Zeolites*, **14**, 523-528 (1994)

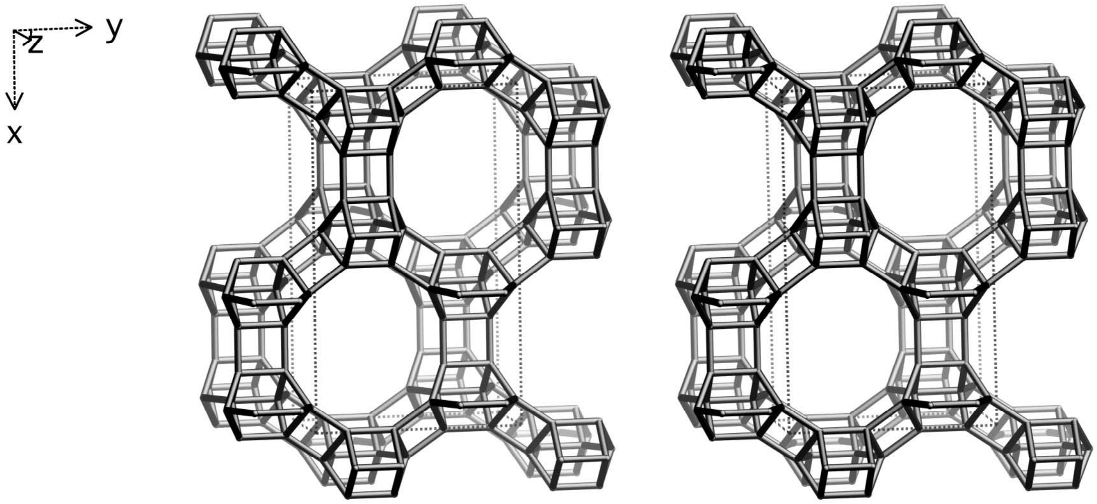
Crystal chemical data: **[**$Al_{10}P_{10}\ O_{40}$**]-AFO**
monoclinic, $P112_1$, a = 9.718Å, b = 13.792Å, c = 8.359Å, γ= 110.6° [1]
(Relationship to unit cell of Framework Type:
a' = a, b' = b·sin(γ)/2, c' = c
or, as vectors, **a'** = **a**, **b'** = (**b** - **a**)/2, **c'** = **c**)

Framework density: 19.1 T/1000Å^3

Channels: [001] **10** 4.3 x 7.0*



10-ring viewed along [001]



framework viewed along [001]

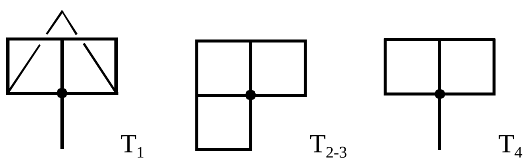
Idealized cell constants: orthorhombic, Pmmn (origin choice 2), a = 22.3Å, b = 13.6Å, c = 7.0Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	16	27	43	63	88	115	141	171	$4\cdot6\cdot4\cdot6_2\cdot4\cdot8$
T_2 (8, 1)	4	9	18	30	43	64	90	111	140	181	$4\cdot4\cdot4\cdot8\cdot6_3\cdot8$
T_3 (8, 1)	4	9	18	29	42	66	93	112	139	177	$4\cdot4\cdot4\cdot12\cdot6\cdot6_3$
T_4 (8, 1)	4	10	17	28	47	65	86	117	144	169	$4\cdot6\cdot4\cdot6\cdot6\cdot12$

Secondary building units: 6-2 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:

*SAPO-40[1-3]
AlPO-40[4]
CoAPSO-40[5]
ZnAPSO-40[5]

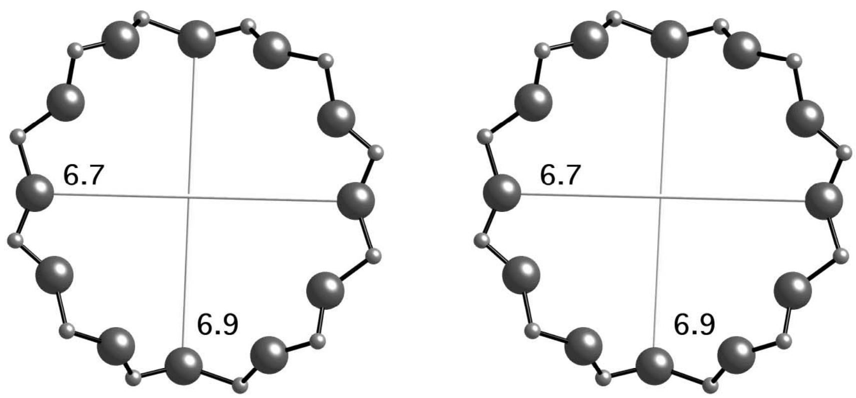
References:

(1) Estermann, M.A., McCusker, L.B. and Baerlocher, Ch. *J. Appl. Crystallogr.*, **25**, 539-543 (1992)
(2) Dumont, N., Gabelica, Z., Derouane, E.G. and McCusker, L.B. *Microporous Materials*, **1**, 149-160 (1993)
(3) McCusker, L.B. and Baerlocher, Ch. *Microporous Materials*, **6**, 51-54 (1996)
(4) Ramaswamy, V., McCusker, L.B. and Baerlocher, Ch. *Microporous and Mesoporous Materials*, **31**, 1-8 (1999)
(5) Lourenco, J.P., Ribeiro, M.F., Borges, C., Rocha, J., Onida, B., Garrone, E. and Gabelica, Z. , **38**, 267-278 (2000)

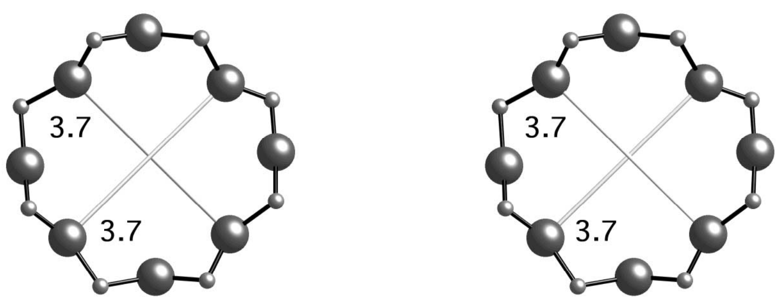
Crystal chemical data: **|**$(C_{12}H_{28}N^+)_4$ $(OH)^-_4$**|** **[**$Si_8Al_{28}P_{28}$ O_{128}**]-AFR**
$C_{12}H_{28}N^+$ = tetrapropylammonium
orthorhombic, Pccn, a = 21.944Å, b = 13.691Å, c = 14.249Å [(3)]
(Relationship to unit cell of Framework Type: a' = a, b' = b, c' = 2c)

Framework density: 15.0 T/1000Å^3

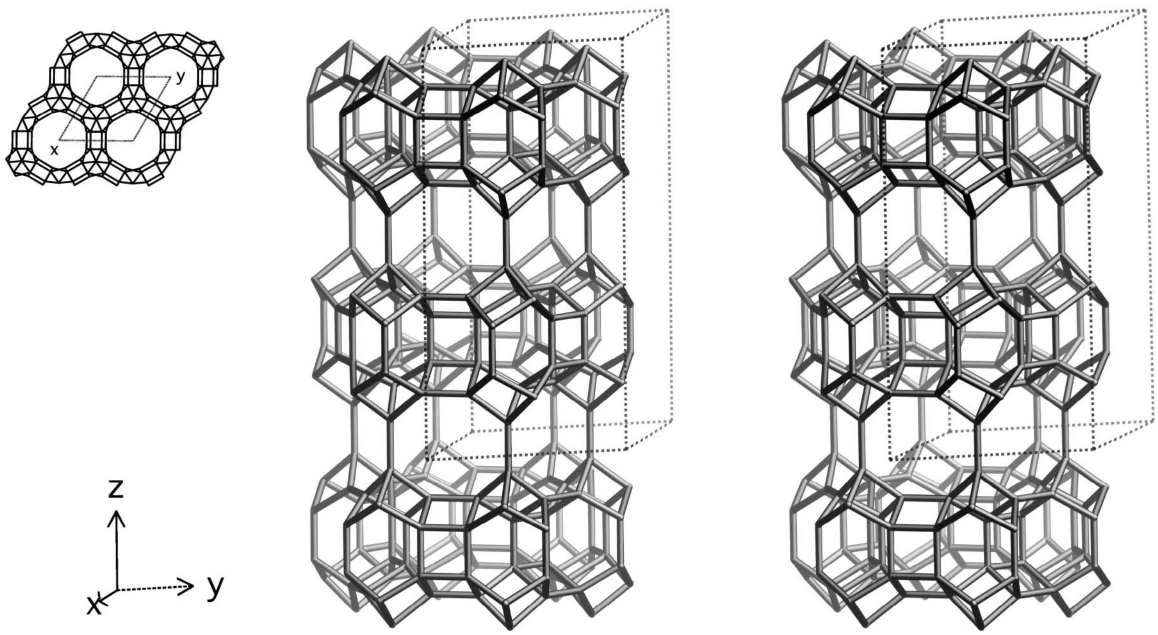
Channels: [001] **12** 6.7 x 6.9* ↔ [010] **8** 3.7 x 3.7*



12-ring viewed along [001]



8-ring viewed along [010]



framework viewed normal to [001] (top left: projection down [001])

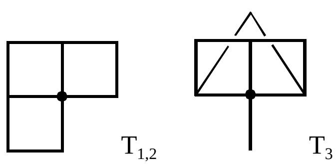
Idealized cell constants: hexagonal, $P6_3/mcm$, a = 13.1Å, c = 25.9Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	28	42	60	83	111	138	166	$4\cdot4\cdot4\cdot8_2\cdot6_2\cdot8$
T_2 (24, 1)	4	9	16	25	39	61	86	109	134	163	$4\cdot4\cdot4\cdot6\cdot6\cdot12$
T_3 (8, 3)	4	9	18	30	43	62	85	105	135	180	$4\cdot8\cdot4\cdot8\cdot4\cdot8$

Secondary building units: 6*1

Loop configuration of T-Atoms:



Isotypic framework structures: *MAPSO-46[1]

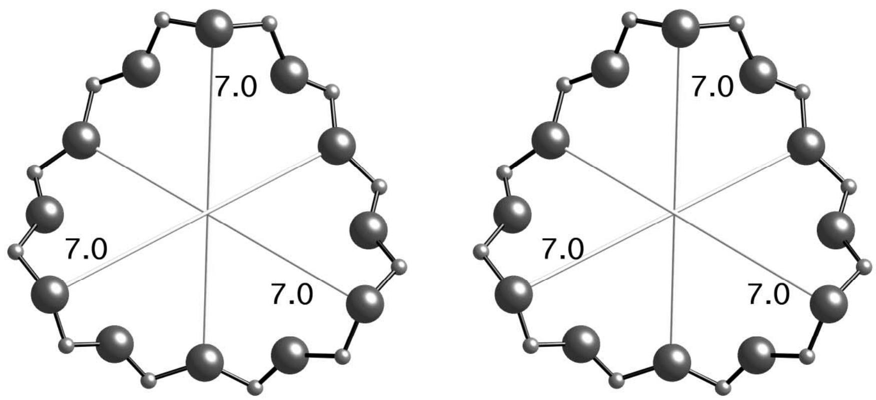
References:

(1) Bennett, J.M. and Marcus, B.K. *Stud. Surf. Sci. Catal.*, **37**, 269-279 (1988)

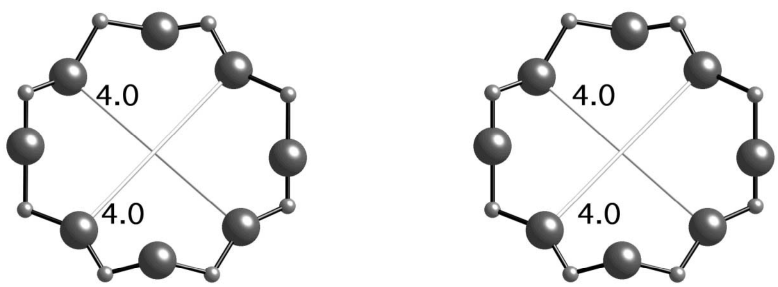
Crystal chemical data: |$(C_6H_{16}N^+)_8$ $(H_2O)_{14}$| **[**$Mg_6Al_{22}P_{26}Si_2$ O_{112}**]-AFS**
$C_6H_{15}N$ = dipropylamine
trigonal, P3c1, a = 13.225Å, c = 26.892Å [(1)]

Framework density: 13.7 T/1000Å^3

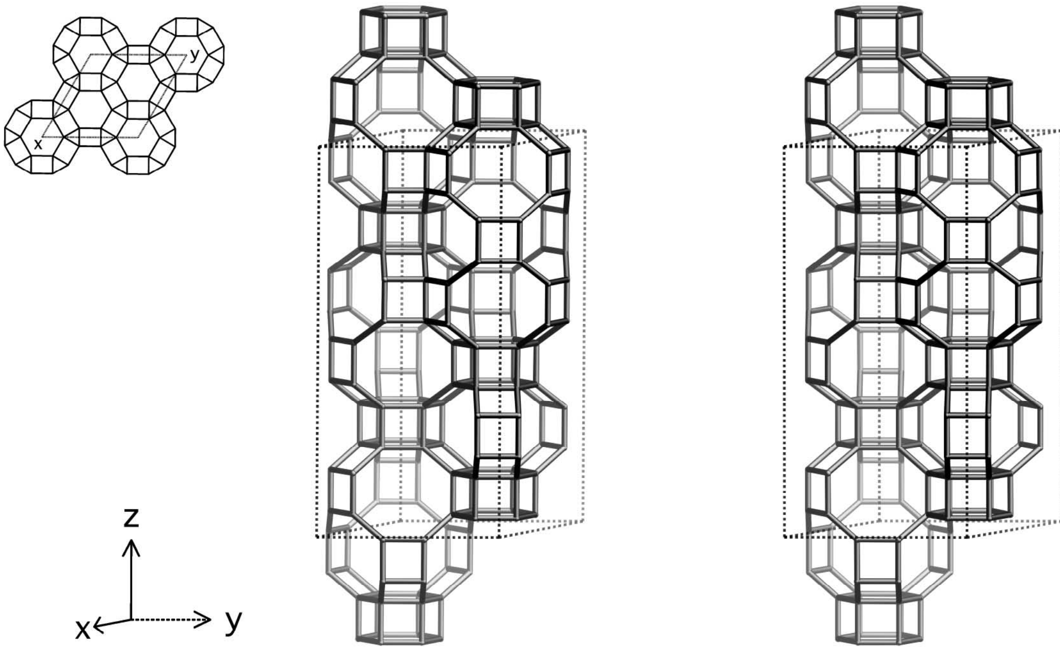
Channels: [001] **12** 7.0 x 7.0* ↔ ⊥[001] **8** 4.0 x 4.0**



12-ring viewed along [001]



8-ring viewed normal to [001]



framework viewed normal to [001] (top left: projection down [001])

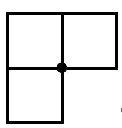
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 13.7Å, c = 29.4Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	29	45	64	85	110	140	173	4·4·4·8·6·8
T_2 (24, 1)	4	9	17	29	45	64	86	113	144	178	4·4·4·8·6·8
T_3 (24, 1)	4	9	17	29	45	65	88	113	141	175	4·4·4·8·6·8

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



T_{1-3}

Framework description: AABBCCAACCBB sequence of 6-rings

Isotypic framework structures: *AlPO-52[1,2]

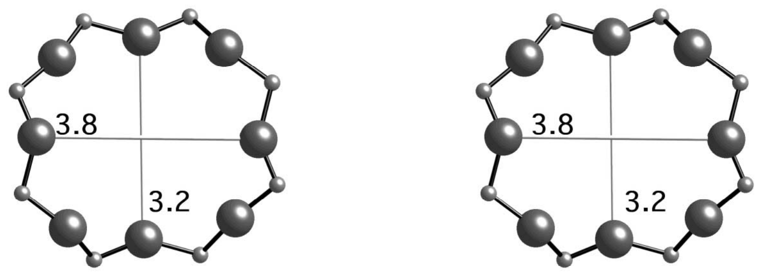
References:

(1) Bennett, J.M., Kirchner, R.M. and Wilson, S.T. *Stud. Surf. Sci. Catal.*, **49**, 731-739 (1989)
(2) McGuire, N.K., Bateman, C.A., Blackwell, C.S., Wilson, S.T. and Kirchner, R.M. *Zeolites*, **15**, 460-469 (1995)

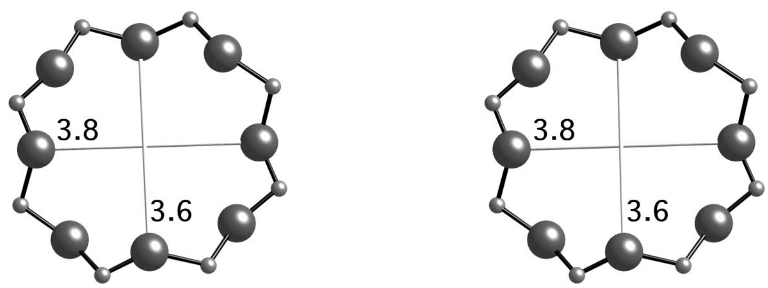
Crystal chemical data: **[**$Al_{36}P_{36}O_{144}$**]-AFT**
trigonal, $P\bar{3}1c$, a = 13.715Å, c = 29.676Å [(2)]

Framework density: 14.9 T/1000Å^3

Channels: ⊥ [001] **8** 3.2 x 3.8***

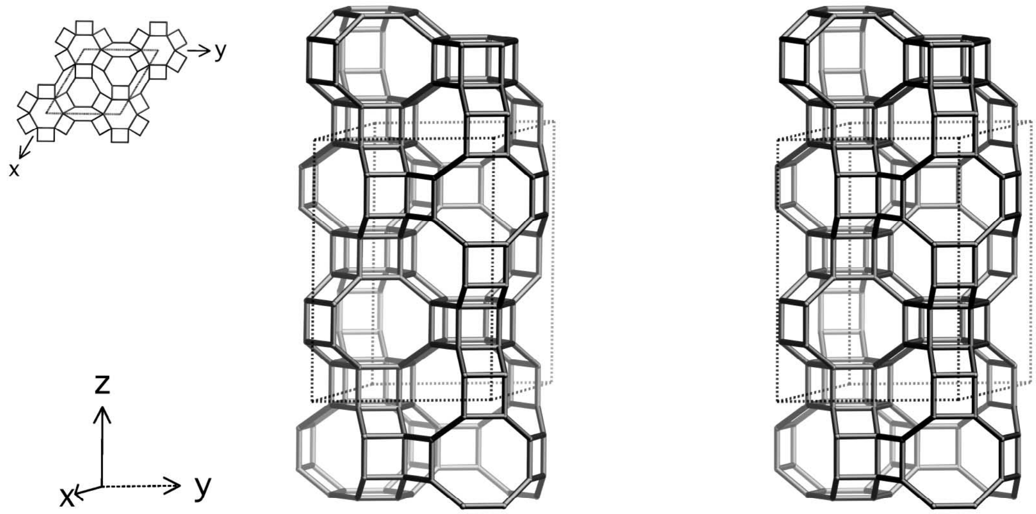


GME cage 8-ring viewed normal to [001]



CHA cage 8-ring viewed normal to [001]

AFX Framework Type $P6_3/mmc$



framework viewed normal to [001] (top left: projection down [001])

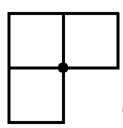
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 13.7Å, c = 19.7Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	29	45	65	89	116	144	175	4·4·4·8·6·8
T_2 (24, 1)	4	9	17	29	45	64	85	110	141	178	4·4·4·8·6·8

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



$T_{1,2}$

Framework description: AABBCCBB sequence of 6-rings

Isotypic framework structures: *SAPO-56[1]
SSZ-16[2]

References:

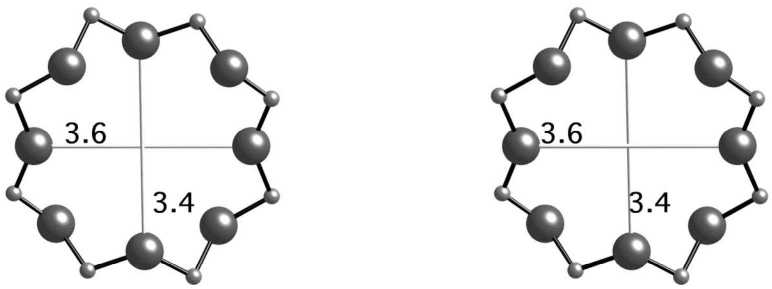
(1) Wilson, S.T., Broach, R.W., Blackwell, C.S., Bateman, C.A., McGuire, N.K. and Kirchner, R.M. *Microporous and Mesoporous Materials*, **28**, 125-137 (1999)

(2) Lobo, R.F., Zones, S.I. and Medrud, R.C. *Chem. Mater.*, **8**, 2409-2411 (1996)

Crystal chemical data: |H^+_3|[$Al_{23}Si_5P_{20}$ O_{96}]-**AFX**
trigonal, $P\bar{3}1c$, a = 13.762Å, c = 19.949Å [(2)]

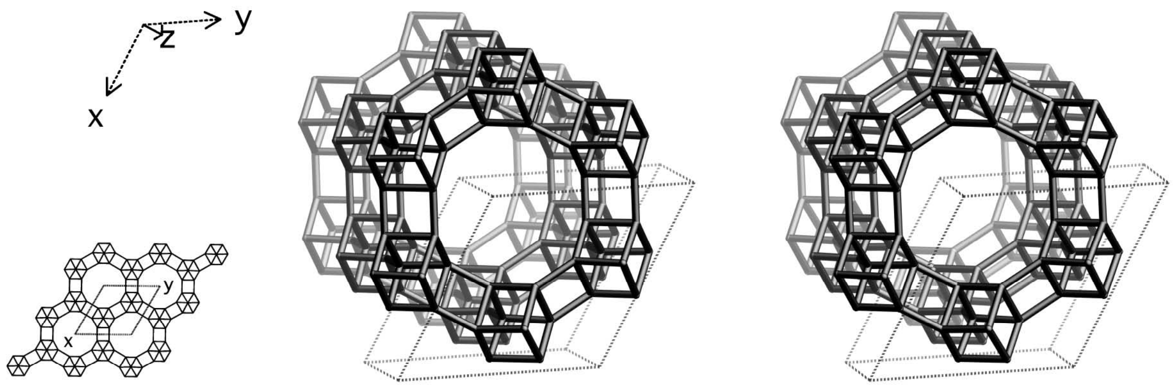
Framework density: 14.7 T/1000$Å^3$

Channels: ⊥[001] **8** 3.4 x 3.6***



8-ring viewed normal to [001]

AFY　　Framework Type　　$P\bar{3}1m$



framework viewed along [001] (bottom left: projection down [001])

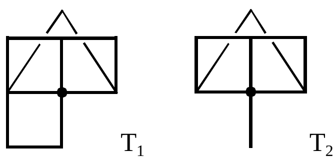
Idealized cell constants: trigonal, $P\bar{3}1m$, a = 12.3Å, c = 8.6Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	8	14	25	39	53	71	96	124	152	4·4·4·8·4·12
T_2 (4, 3)	4	9	16	23	34	57	82	98	115	141	4·8·4·8·4·8

Secondary building units: 4-4 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *CoAPO-50[1,2]
MgAPO-50[3]

References:

(1) Wilson, S.T. private communication
(2) Bennett, J.M. and Marcus, B.K. Stud. Surf. Sci. Catal., **37**, 269-279 (1988)
(3) Akolekar, D.B. Zeolites, **15**, 583-590 (1995)

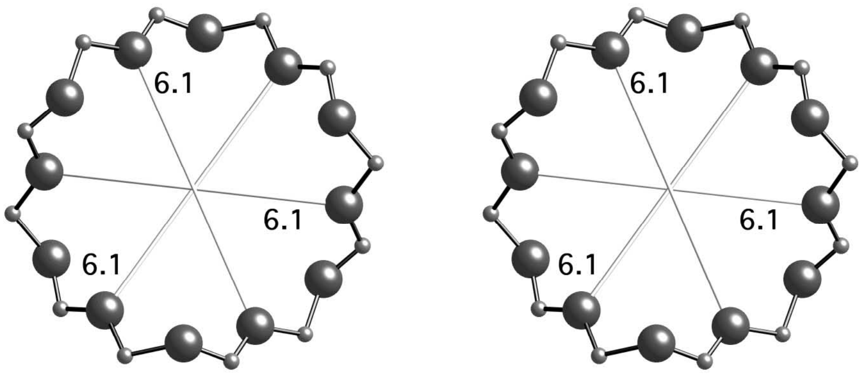
CoAPO-50 Type Material AFY

Crystal chemical data: **|**$(C_6H_{16}N^+)_3$ $(H_2O)_7$**|** **[**$Co_3Al_5P_8$ O_{32}**]-AFY**
$C_6H_{15}N$ = dipropylamine
trigonal, $P\overline{3}$, a = 12.747Å, c = 9.015Å [(2)]

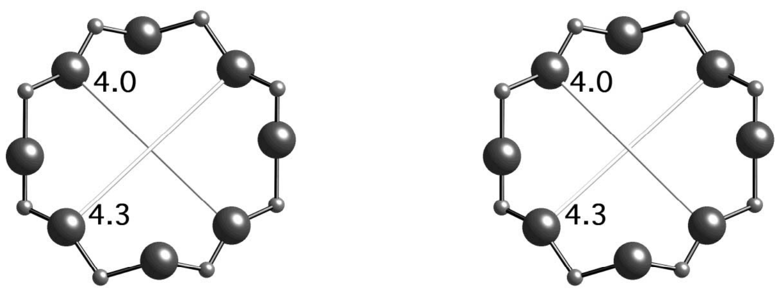
Framework density: 12.6 T/1000$Å^3$

Channels: [001] **12** 6.1 x 6.1* ↔ ⊥ [001] **8** 4.0 x 4.3**

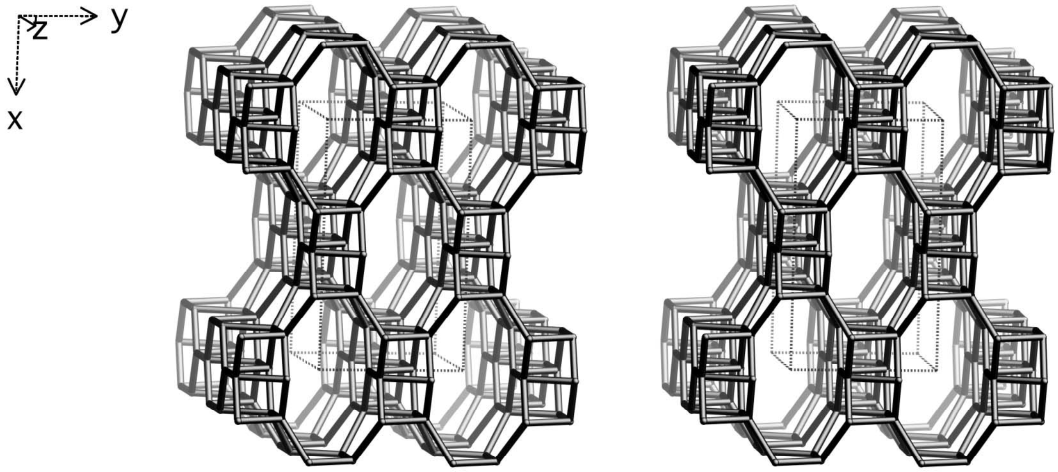
Stability: Unstable to removal of template [(1)]



12-ring viewed along [001]



8-ring viewed normal to [001]



framework viewed along [001]

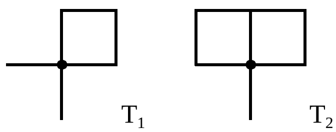
Idealized cell constants: orthorhombic, Cmcm, a = 15.8Å, b = 9.2Å, c = 8.6Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	21	36	56	81	109	142	179	221	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6 \cdot 6_3$
T_2 (8, m)	4	10	18	32	53	78	105	140	179	218	$4 \cdot 6_3 \cdot 4 \cdot 6_3 \cdot 6 \cdot 6_4$

Secondary building units: 4-2

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-H2[1-2]

References:

(1) Li, H.X., Davis, M.E., Higgins, J.B. and Dessau, R.M. *Chem. Commun.*, 403-405 (1993)

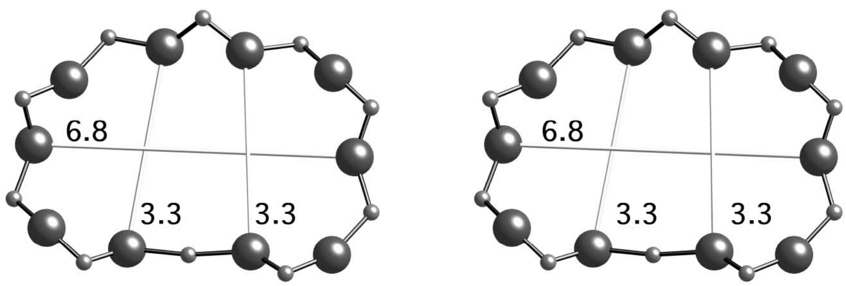
(2) Kennedy, G.J., Higgins, J.B., Ridenour, C.F., Li, H.X. and Davis, M.E. *Solid State Nucl. Mag. Res.*, **4**, 173-178 (1995)

Crystal chemical data: |$(H_2O)_8$| **[**$Al_6P_6O_{24}$ **]-AHT**
monoclinic, $P112_1$, a = 9.486Å, b = 9.914Å, c = 8.126Å, γ = 121.49° (1)
(Relationship to unit cell of Framework Type: a'= a/2 sin(γ), b' = b, c' = c
or, as vectors, **a'** = (**a** - **b**)/2, **b'** = **b**, **c'** = **c**)

Framework density: 18.4 T/1000Å^3

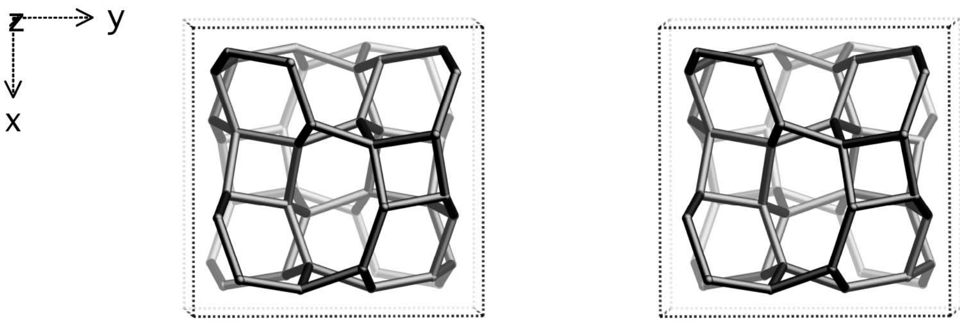
Channels: [001] **10** 3.3 x 6.8*

Stability: Transforms to $AlPO_4$-tridymite on heating(2)



10-ring viewed along [001]

ANA Framework Type $Ia\bar{3}d$



framework viewed along [001]

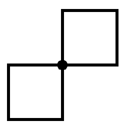
Idealized cell constants: cubic, $Ia\bar{3}d$, a = 13.6Å

Coordination sequences and vertex symbols:

T_1	(48, 2)	4	10	22	39	60	87	118	154	196	242	$4 \cdot 4 \cdot 6 \cdot 6 \cdot 8_4 \cdot 8_4$

Secondary building units: 6-2 or 6 or 4

Loop configuration of T-Atoms:



T_1

Isotypic framework structures:

*Analcime[1-3]
[Al-Co-P-O**]-ANA**[4]
[Al-Si-P-O**]-ANA**[5]
[Ga-Ge-O**]-ANA**[6]
|Cs-Na-(H_2O)**|** **[**Ga-Si-O**]-ANA**[7]
|Cs_{16}**|[**$Cu_8Si_{40}O_{96}$**]-ANA**[8]
|K-**|[**B-Si-O**]-ANA**[9]
AlPO-24[10]
$AlPO_4$-pollucite[11]
Ammonioleucite[12]
Ca-D[13]
Cs beryllosilicate pollucite[14]
Cs,Fe silicate pollucite[15]
Hsianghualite[16]
Kehoeite[17]
Leucite[18]
Na-B[19]
Pollucite[20]
Synthetic analcime[21]
Synthetic hsinghualite[22]
Synthetic wairakite[23]
Wairakite and additional compositional variants[24]

Alternate designation: Analcite

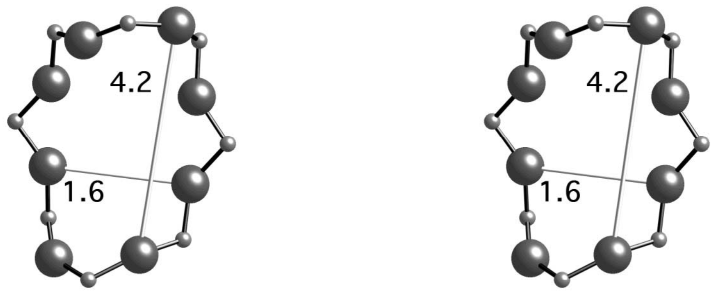
References:

(1) Taylor, W.H. *Z. Kristallogr.*, **74**, 1-19 (1930)
(2) Knowles, C.R., Rinaldi, F.F. and Smith, J.V. *Indian Mineral.*, **6**, 127- (1965)
(3) Ferraris, G., Jones, D.W. and Yerkess, J. *Z. Kristallogr.*, **135**, 240-252 (1972)
(4) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(5) Artioli, G., Pluth, J.J. and Smith, J.V. *Acta Crystallogr.*, **C40**, 214-217 (1984)
(6) Bu, X., Feng, P., Gier, T.E., Zhao, D. and Stucky, G.D. *J. Am. Chem. Soc.*, **120**, 13389-13397 (1998)

Crystal chemical data: |Na^+_{16} $(H_2O)_{16}$| [$Al_{16}Si_{32}$ O_{96}]-**ANA**
cubic, Ia$\bar{3}$d, a = 13.73Å (3)

Framework density: 18.5 T/1000Å^3

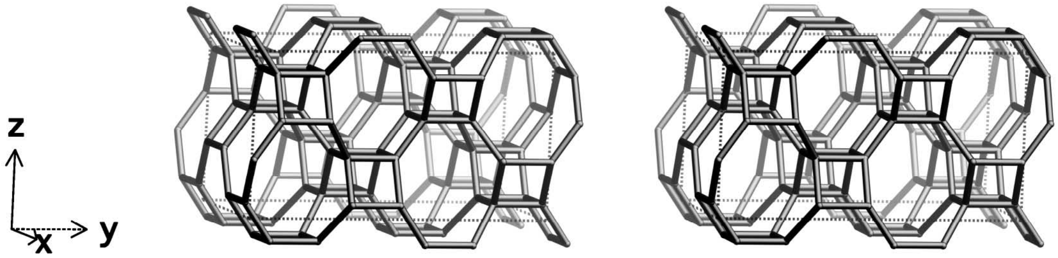
Channels: irregular channels formed by highly distorted 8-rings



distorted 8-ring viewed along [110]

References (cont.):

(7) Yelon, W.B., Xie, D., Newsam, J.M. and Dunn, J. *Zeolites*, **10**, 553-558 (1990)
(8) Heinrich, A.R. and Baerlocher, Ch. *Acta Crystallogr.*, **C47**, 237-241 (1991)
(9) Millini, R., Montanari, L. and Bellussi, G. *Microporous Materials*, **1**, 9-15 (1993)
(10) Wilson, S.T., Lok, B.M., Messina, C.A., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **104**, 1146-1147 (1982)
(11) Keller, E.B. *Ph.D. Thesis, ETH, Zürich, Switzerland*, (1987)
(12) Hori, H., Nagashima, K., Yamada, M., Miyawaki, R. and Marubashi, T. *Am. Mineral.*, **71**, 1022-1027 (1986)
(13) Ames, L.L. and Sand, L.B. *Am. Mineral.*, **43**, 476-480 (1958)
(14) Torres-Martines, L.M., Gard, J.A., Howie, R.A. and West, A.R. *J. Solid State Chem.*, **51**, 100-103 (1984)
(15) Kopp, O.C., Harris, L.A., Clark, G.W. and Yakel, H.L. *Am. Mineral.*, **48**, 100-109 (1963)
(16) Wen-Hui, H., Saho-Hua, T., Kung-Hai, W., Chun-Lin, C. and Cheng Chi, Y. *Am. Mineral.*, **44**, 1327-1328 (1959)
(17) McConnell, D. and Foreman Jr., D.W. *Can. Mines*, **12**, 352- (1974)
(18) Peacor, D.R. *Z. Kristallogr.*, **127**, 213-224 (1968)
(19) Barrer, R.M. and White, E.A.D. *J. Chem. Soc.*, 1561-1571 (1952)
(20) Nel, H.J. *Am. Mineral.*, **29**, 443-451 (1944)
(21) Ghobarkar, H. and Franke, W. *Cryst. Res. Technol.*, 1071-1075 (1986)
(22) Ghobarkar, H., Schaef, O. and Knauth, Pl *Annal. Chimie, Science Matériaux*, **24**, 209-215 (1999)
(23) Ghobarkar, H. *Cryst. Res. Technol.*, K90-92 (1985)
(24) Takeuchi, Y., Mazzi, F., Haga, N. and Galli, E. *Am. Mineral.*, **64**, 993-1001 (1979)



framework viewed along [100]

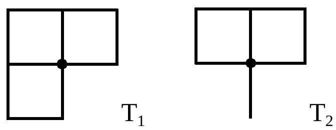
Idealized cell constants: orthorhombic, Cmca, a = 9.0Å, b = 19.4Å, c = 10.4Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	19	35	53	75	102	132	168	208	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8_2$
T_2 (16, 1)	4	10	20	35	54	76	104	136	171	211	$4\cdot6\cdot4\cdot6\cdot6\cdot8_2$

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*AlPO-C[1,2]
AlPO-H3[3]

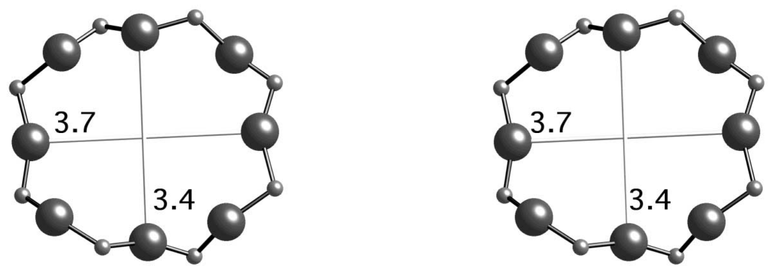
References:
(1) Bennett, J.M., Dytrych, W.J., Pluth, J.J., Richardson Jr., J.W. and Smith, J.V. *Zeolites*, **6**, 349-359 (1986)
(2) Keller, E.B., Meier, W.M. and Kirchner, R.M. *Solid State Ionics*, **43**, 93-102 (1990)
(3) Pluth, J.J. and Smith, J.V. *Acta Crystallogr.*, **C42**, 1118-1120 (1986)

Crystal chemical data: **[** $Al_{16}P_{16}O_{64}$ **]-APC**
orthorhombic, Pbca, a = 19.821Å, b = 10.028Å, c = 8.936Å [(2)]
(Relationship to unit cell of Framework Type: a'= b, b' = c, c' = a)

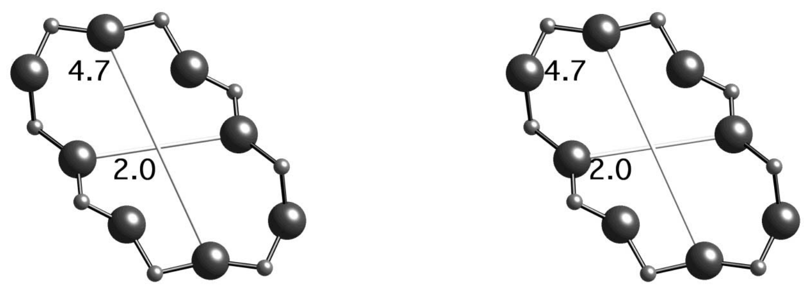
Framework density: 18.0 T/1000Å^3

Channels: [001] **8** 3.4 x 3.7* ↔ [100] **8** 2.0 x 4.7*

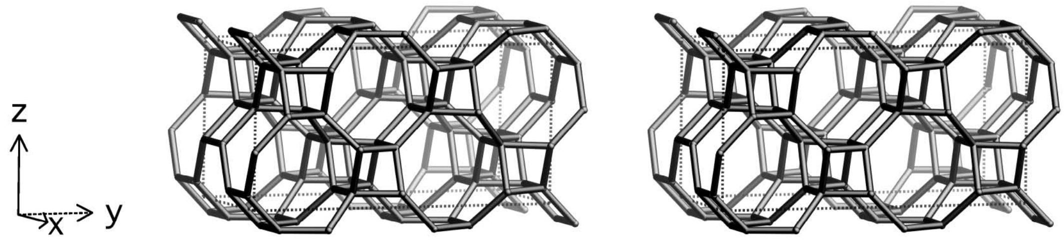
Stability: Transforms to $AlPO_4$-D at ca 250ºC [(2)]



8-ring viewed along [001]



distorted 8-ring viewed along [100]



framework viewed along [100]

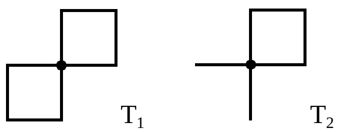
Idealized cell constants: orthorhombic, Cmca, a = 8.7Å, b = 20.1Å, c = 10.2Å

Coordination sequences and vertex symbols:

T_1	(16, 1)	4	10	21	37	57	82	112	145	184	228	$4 \cdot 4 \cdot 6_2 \cdot 8_3 \cdot 6_3 \cdot 8_3$
T_2	(16, 1)	4	11	22	38	59	83	113	147	186	230	$4 \cdot 6_2 \cdot 6 \cdot 6_2 \cdot 6 \cdot 6_3$

Secondary building units: 8 or 6-2 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-D[1]

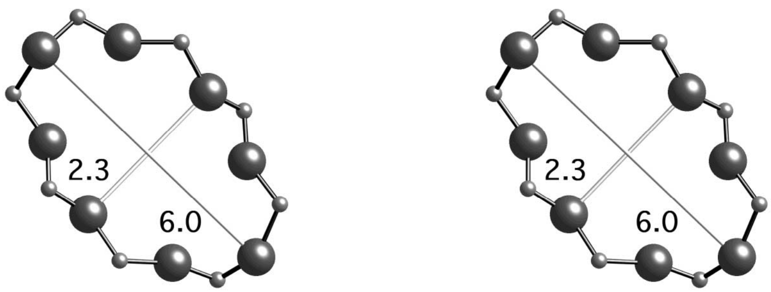
References:

(1) Keller, E.B., Meier, W.M. and Kirchner, R.M. *Solid State Ionics*, **43**, 93-102 (1990)

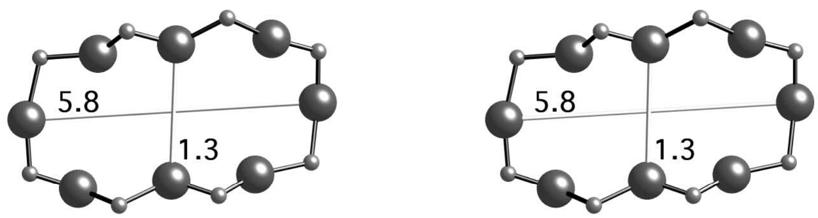
Crystal chemical data: **[**$Al_{16}P_{16}$ O_{64}**]-APD**
(forms irreversibly from $AlPO_4$-C at around 200°C)
orthorhombic, $Pca2_1$, a = 19.187Å, b = 8.576Å, c = 9.804Å [(1)]
(Relationship to unit cell of Framework Type: a' = b, b' = a, c' = c)

Framework density: 19.8 T/1000Å^3

Channels: [010] **8** 2.3 x 6.0* ↔ [201] **8** 1.3 x 5.8*

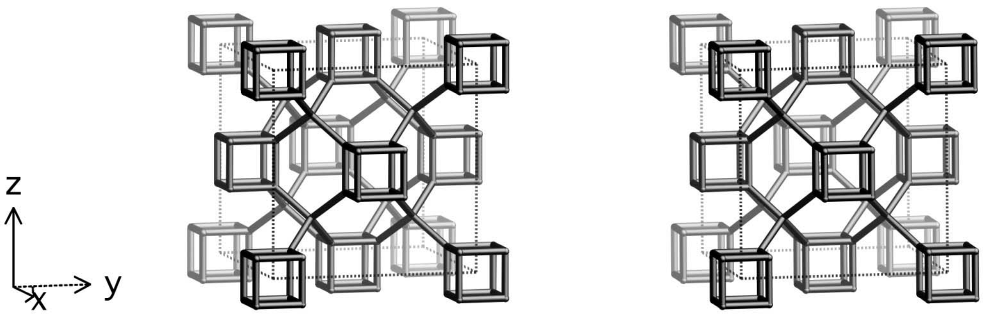


distorted 8-ring viewed along [010]



distorted 8-ring along [201]

AST Framework Type $Fm\bar{3}m$



framework viewed along [100]

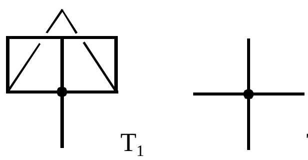
Idealized cell constants: cubic, $Fm\bar{3}m$, a = 13.6Å

Coordination sequences and vertex symbols:

T_1 (32, 3m)	4	9	19	34	48	66	96	127	151	183	4·6·4·6·4·6
T_2 (8, $\bar{4}$3m)	4	12	18	28	52	78	88	112	162	204	6·6·6·6·6·6

Secondary building units: 4-1

Loop configuration of T-Atoms:



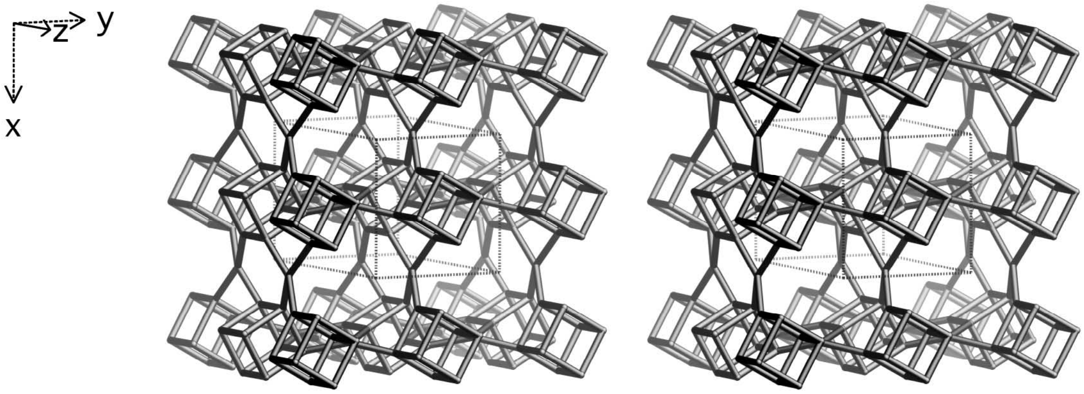
T_1 T_2

Framework description: structural derivative of fluorite

Isotypic framework structures:
*AlPO-16[1]
Octadecasil[2]

References:
(1) Bennett, J.M. and Kirchner, R.M. *Zeolites*, **11**, 502-506 (1991)
(2) Caullet, P., Guth, J.L., Hazm, J., Lamblin, J.M. and Gies, H. *Eur. J. Solid State Inorg. Chem.*, **28**, 345-361 (1991)

Crystal chemical data:	|$(C_7H_{13}N)_4$ $(H_2O)_{16}$| **[**$Al_{20}P_{20}$ O_{80}**]-AST** $C_7H_{13}N$ = quinuclidine cubic, F23, a = 13.383Å [1]
Framework density:	16.7 T/1000Å^3
Channels:	apertures formed by 6-rings only



framework viewed along [001]

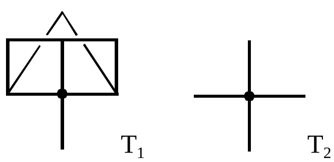
Idealized cell constants: tetragonal, P4/mcc, a = 8.7Å, c = 13.9Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	19	35	52	72	100	131	163	201	4·6·4·6·4·6
T_2 (4, 222)	4	12	18	26	52	84	100	118	162	210	$6\cdot6\cdot6_2\cdot6_2\cdot12_8\cdot12_8$

Secondary building units: 4-1

Loop configuration of T-Atoms:



Isotypic framework structures: *ASU-7[1]

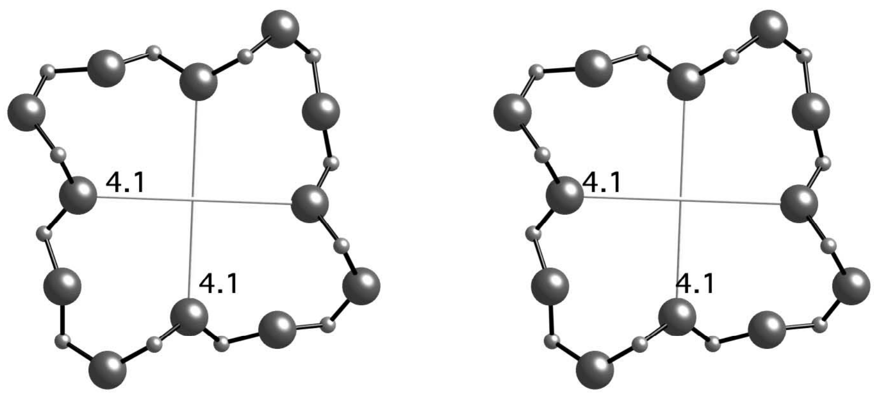
References:

(1) Li, H. and Yaghi, O.M. *J. Am. Chem. Soc.*, **120**, 10569-10570 (1998)

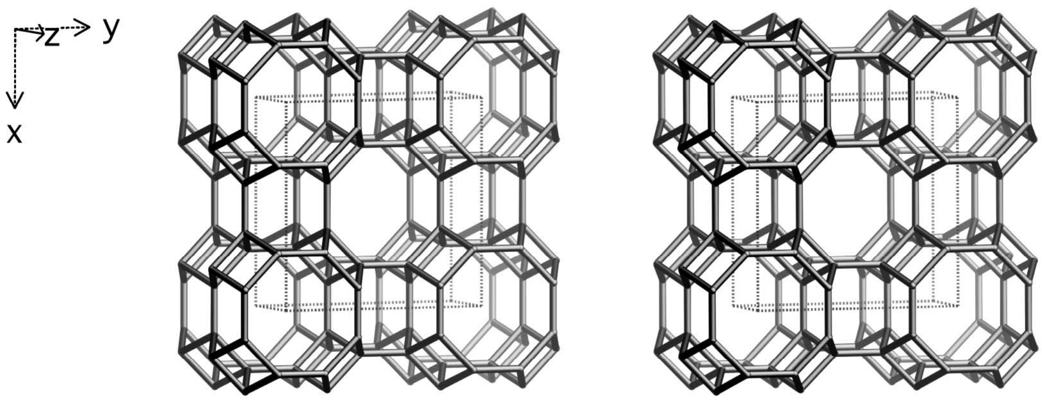
Crystal chemical data: **|**$(C_2H_7N)_2$ $(H_2O)_2$**| [**Ge_{20} O_{40}**]-ASV**
C_2H_7N = dimethylamine
tetragonal, P4/mcc, a = 8.780Å, c = 14.470Å [(1)]

Framework density: 17.9 T/1000Å^3

Channels: [001] **12** 4.1x 4.1*



12-ring along [001]



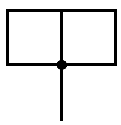
framework viewed along [001]

Idealized cell constants: tetragonal, I4/mmm, a = 13.1Å, c = 5.3Å

Coordination sequences and vertex symbols: T_1 (16, m) 4 10 21 36 54 78 106 136 173 214 4·6·4·6·6·8

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



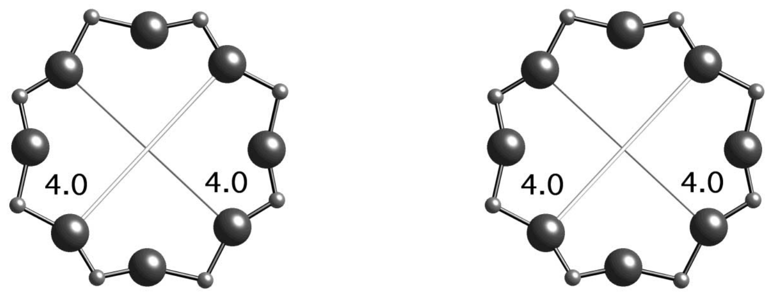
Isotypic framework structures: *MAPO-39[1,2]

References:
(1) McCusker, L.B., Brunner, G.O. and Ojo, A.F. *Acta Crystallogr.*, **A46**, C59 (1990)
(2) Baur, W.H., Joswig, W., Kassner, D., Bieniok, A., Finger, G. and Kornatowski, J. *Z. Kristallogr.*, **214**, 154-159 (1999)

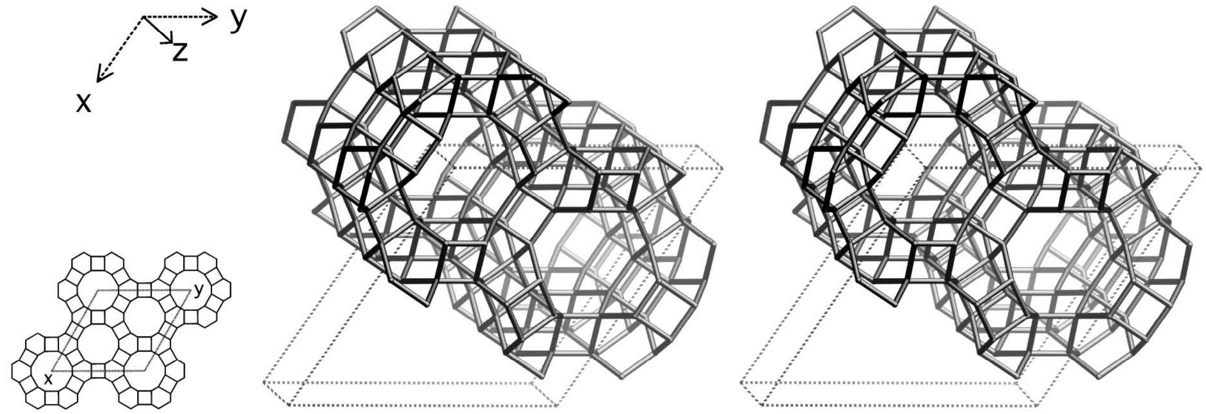
Crystal chemical data: |H^+_n| [$Mg_nAl_{8-n}P_8O_{32}$]-**ATN**
tetragonal, I4/m, a = 13.209Å, c = 5.277Å (2)

Framework density: 18.0 T/1000Å^3

Channels: [001] **8** 4.0 x 4.0*



8-ring viewed along [001]



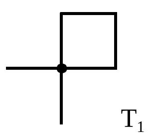
framework viewed along [001]

Idealized cell constants: trigonal, R$\bar{3}$m, a = 20.9Å, c = 5.1Å

Coordination sequences and vertex symbols: T_1 (36, 1) 4 11 22 37 59 85 114 147 184 230 $4\cdot6_2\cdot6\cdot6_2\cdot6\cdot6_3$

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



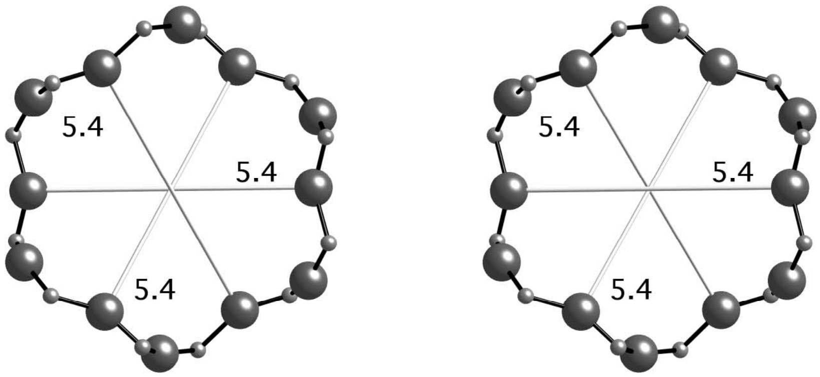
Isotypic framework structures:
*AlPO-31[1,2]
SAPO-31[3-5]

References:
(1) Bennett, J.M. and Kirchner, R.M. *Zeolites*, **12**, 338-342 (1992)
(2) Baur, W.H., Joswig, W., Kassner, D. and Kornatowski, J. *Acta Crystallogr.*, **B50**, 290-294 (1994)
(3) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)
(4) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (ed. eds. Y. Murakami, A. Iijima and J.W. Ward), pp. pp. 103-112 (1986), Kodansha, Tokyo
(5) Baur, W.H., Joswig, W., Kassner, D. and Kornatowski, J. *Acta Crystallogr.*, **B50**, 290-294 (1994)

Crystal chemical data: **[**$Al_{18}P_{18}O_{72}$**]-ATO**
trigonal, $R\bar{3}$, a = 20.827Å, c = 5.003Å [(1)]

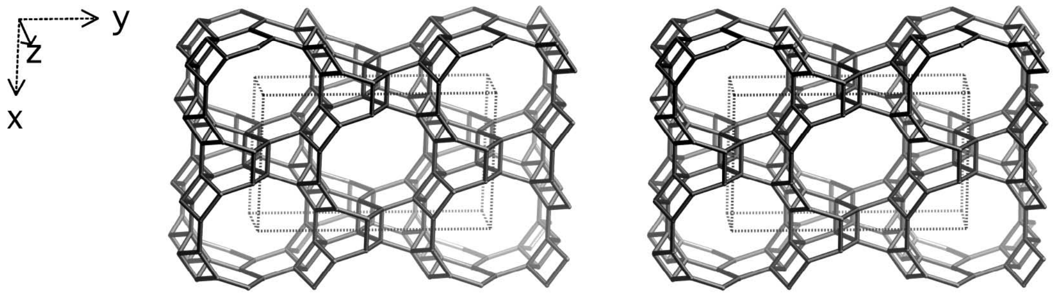
Framework density: 19.2 T/1000Å^3

Channels: [001] **12** 5.4 x 5.4*



12-ring viewed along [001]

ATS Framework Type Cmcm



framework viewed along [001]

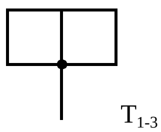
Idealized cell constants: orthorhombic, Cmcm, a = 13.2Å, b = 21.6Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	10	19	30	46	67	93	124	154	189	$4 \cdot 6 \cdot 4 \cdot 6 \cdot 6 \cdot 6_2$
T_2 (8, m)	4	10	20	32	49	73	97	124	157	193	$4 \cdot 6_2 \cdot 4 \cdot 6_2 \cdot 6 \cdot 12_2$
T_3 (8, m)	4	10	19	32	51	72	96	124	155	196	$4 \cdot 6_2 \cdot 4 \cdot 6_2 \cdot 6 \cdot 12_2$

Secondary building units: 6-2 or 4-2 or 6 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *MAPO-36[1]

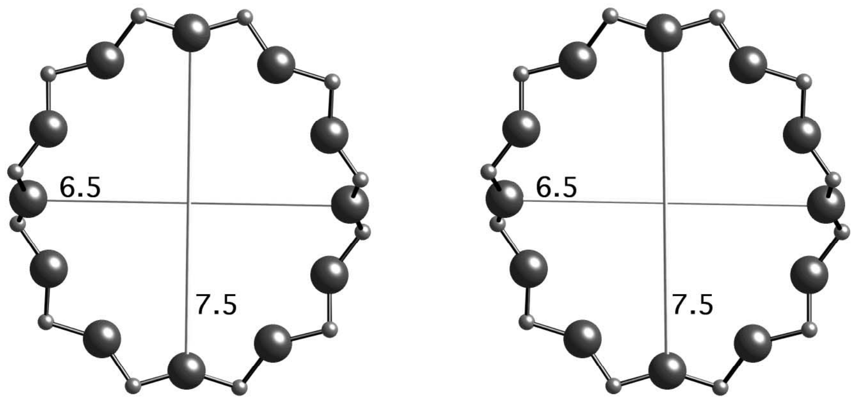
References:

(1) Smith, J.V., Pluth, J.J. and Andries, K.J. *Zeolites*, **13**, 166-169 (1993)

Crystal chemical data: |H^+| [$MgAl_{11}P_{12}O_{48}$]-**ATS**
monoclinic, C12/c1
a = 13.148Å, b = 21.577Å, c = 5.164Å, β = 91.84° [(1)]

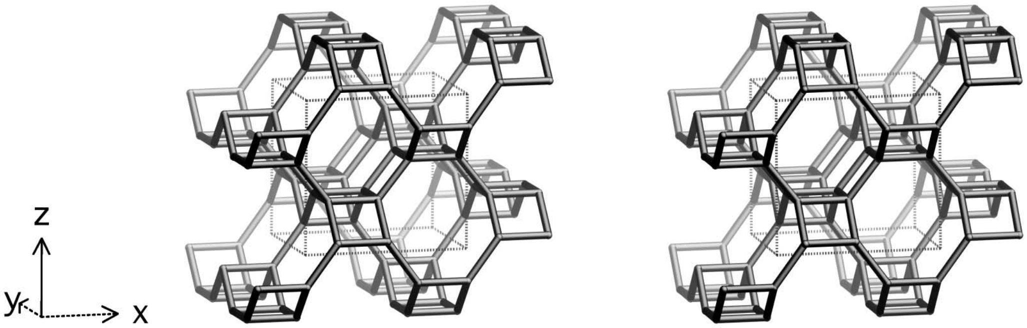
Framework density: 16.4 T/1000$Å^3$

Channels: [001] **12** 6.5 x 7.5*



12-ring viewed along [001]

ATT Framework Type Pmma



framework viewed along [010]

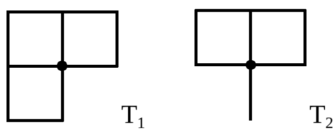
Idealized cell constants: orthorhombic, Pmma, a = 10.0Å, b = 7.5Å, c = 9.4Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	18	33	52	73	96	123	158	199	4·4·4·6·8·8
T_2 (4, m)	4	10	21	34	48	70	100	130	159	194	$4 \cdot 8_2 \cdot 4 \cdot 8_2 \cdot 6 \cdot 8_2$

Secondary building units: 6-2 or 4-2 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*AlPO-12-TAMU[1]
AlPO-33[2,3]

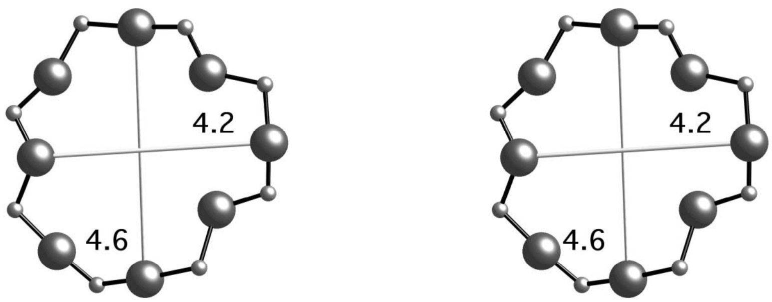
References:

(1) Rudolf, P.R., Saldarriaga-Molina, C. and Clearfield, A. *J. Phys. Chem.*, **90**, 6122-6125 (1986)
(2) Smith, J.V., Pluth, J.J. and Bennett, J.M. *private communication*
(3) Patton, R.L. and Gajek, R.T. *U.S. Patent 4,473,663* (1984)

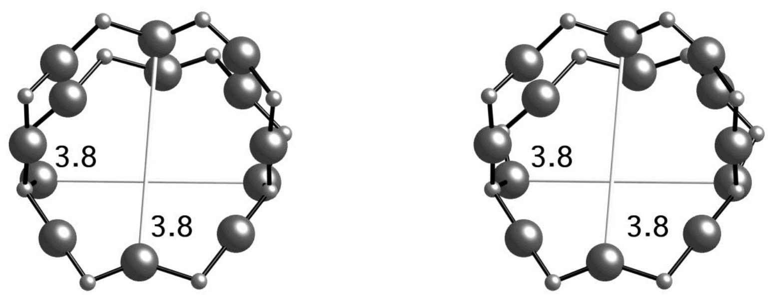
Crystal chemical data: **|**$(C_4H_{12}N^+)_4\ (OH)^-_4$**| [**$Al_{12}P_{12}\ O_{48}$**]-ATT**
$C_4H_{12}N^+$ = tetramethylammonium
orthorhombic, $P2_12_12$, a = 10.332Å, b = 14.640Å, c = 9.511Å [(1)]
(Relationship to unit cell of Framework Type: a' = a, b' = 2b, c' = c)

Framework density: 16.7 T/1000Å^3

Channels: [100] **8** 4.2 x 4.6* ↔ [010] **8** 3.8 x 3.8*

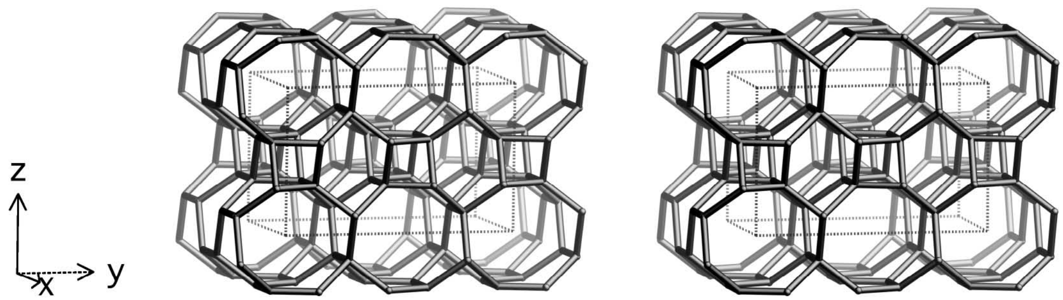


8-ring viewed along [100]



complex 8-ring viewed along [010]

ATV Framework Type Cmma



framework viewed along [100]

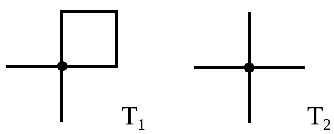
Idealized cell constants: orthorhombic, Cmma, a = 8.6Å, b = 15.3Å, c = 9.7Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	22	40	64	92	121	157	200	248	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_2 (8, m)	4	12	25	42	61	88	122	160	200	246	$6 \cdot 6_2 \cdot 6 \cdot 6_2 \cdot 6_2 \cdot 6_2$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-25[1]
[Ga-P-O**]-ATV**[2]

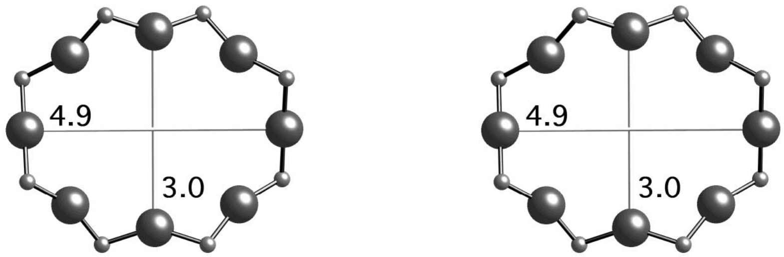
References:

(1) Richardson Jr., J.W., Smith, J.V. and Pluth, J.J. *J. Phys. Chem.*, **94**, 3365-3367 (1990)
(2) Parise, J.B. *Chem. Commun.*, 606-607 (1985)

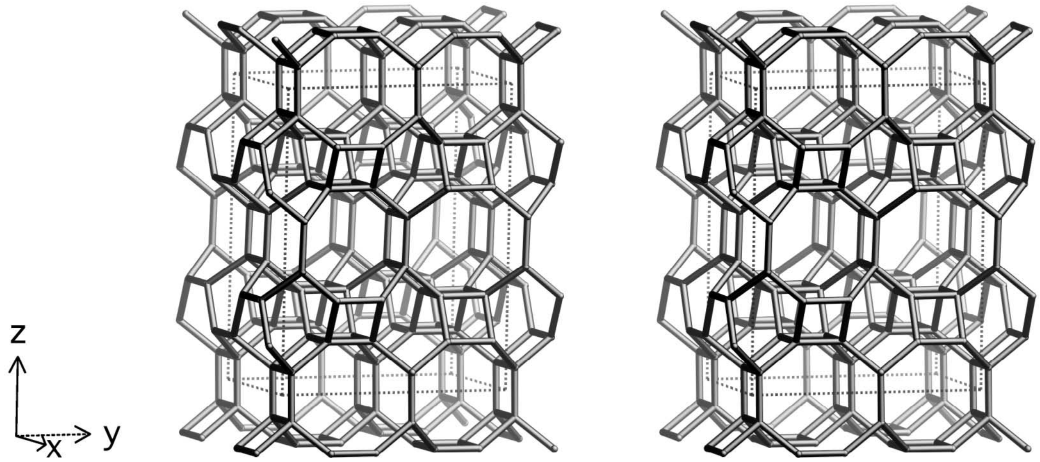
Crystal chemical data: **[**$Al_{12}P_{12}$ O_{48}**]-ATV**
orthorhombic, Acmm, a = 9.449Å, b = 15.203Å, c = 8.408Å [(1)]
(Relationship to unit cell of Framework Type: a' = c, b' = b, c' = a)

Framework density: 19.9 T/1000Å^3

Channels: [001] **8** 3.0 x 4.9*



8-ring viewed along [001]



framework viewed along [100]

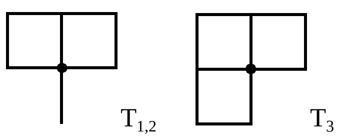
Idealized cell constants: orthorhombic, Cmca, a = 9.1Å, b = 15.0Å, c = 19.2Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	10	20	35	55	78	103	133	173	217		$4\cdot6_2\cdot4\cdot8_3\cdot6\cdot8_2$
T_2 (16, 1)	4	10	21	36	53	76	108	142	173	210		$4\cdot6\cdot4\cdot8_2\cdot6\cdot8$
T_3 (16, 1)	4	9	19	35	54	76	102	134	172	214		$4\cdot4\cdot4\cdot6\cdot8\cdot8_3$

Secondary building units: 6

Loop configuration of T-Atoms:



Isotypic framework structures: *AlPO-21[1,2]
[Ga-P-O**]-AWO**[3]

References:
(1) Bennett, J.M., Cohen, J.M., Artioli, G., Pluth, J.J. and Smith, J.V. *Inorg. Chem.*, **24**, 188-193 (1985)
(2) Parise, J.B. and Day, C.S. *Acta Crystallogr.*, **C41**, 515-520 (1985)
(3) Parise, J.B. *Chem. Commun.*, 606-607 (1985)

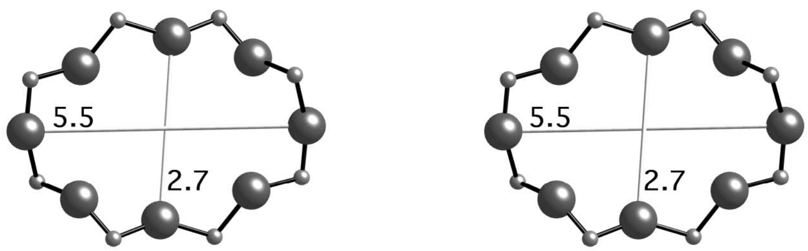
AlPO-21 **Type Material** **AWO**

Crystal chemical data: |H^+_4 $(C_2H_7N)_{10.66}$ $(C_3H_8)_{5.33}$ $(OH)^-_4$| **[**$Al_{12}P_{12}O_{48}$**]-AWO**
C_2H_7N = dimethylamine , C_3H_8 = propane
monoclinic, $P12_1/a1$
a = 10.330Å, b = 17.524Å, c = 8.676Å, β= 123.37° (1)
(Relationship to unit cell of Framework Type:
a' = a, b' = c, c '= b/ 2sin(β)
or, as vectors, **a'** = **a**, **b'** = **c**, **c'** = (**b - a**)/2)

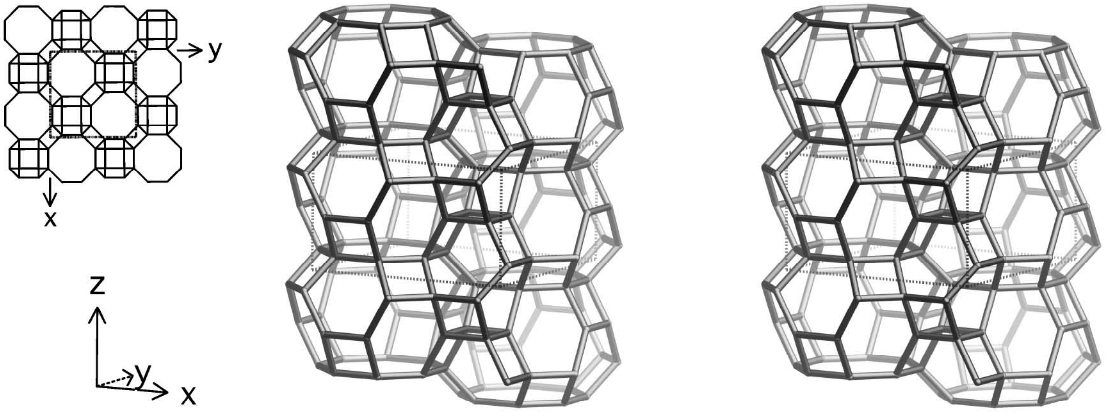
Framework density: 18.3 T/1000Å^3

Channels: [100] **8** 2.7 x 5.5*

Stability: Transforms to AlPO-25 (**ATV**) upon calcination(2)



8-ring viewed along [100]



framework viewed normal to [001] (top left: projection down [001])

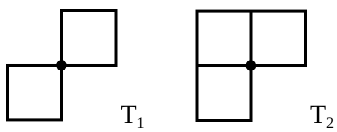
Idealized cell constants: tetragonal, P4/nmm (origin choice 2), a = 13.6Å, c = 7.6Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	10	20	33	50	72	98	128	162	200	4·4·6·6·6·8
T_2 (8, 2)	4	9	17	30	50	74	97	123	158	198	4·4·4·6·6·6

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



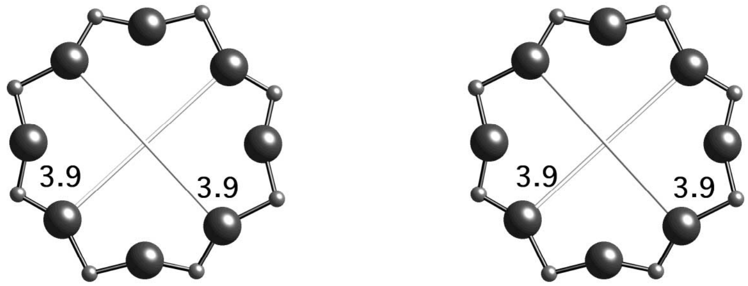
Isotypic framework structures: *AlPO-22[1]

References:
(1) Richardson Jr., J.W., Pluth, J.J. and Smith, J.V. *Naturwiss.*, **76**, 467-469 (1989)

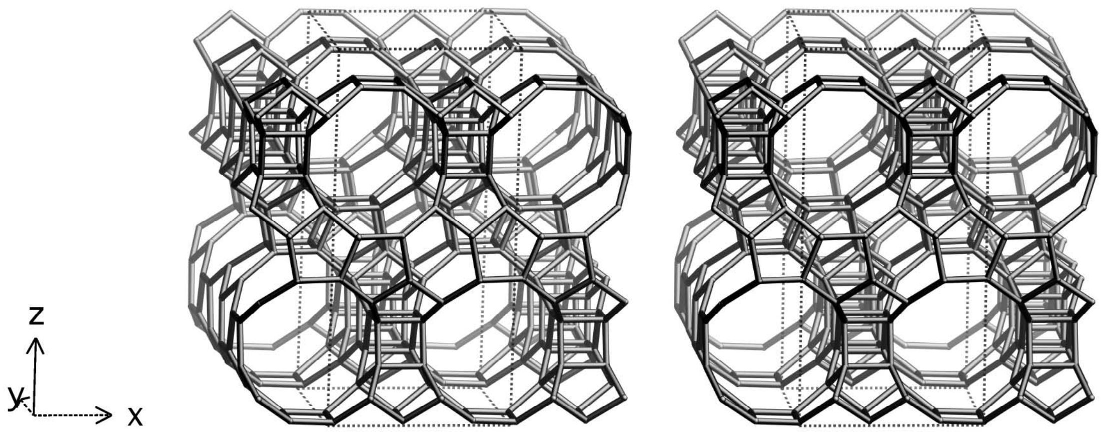
Crystal chemical data: **|**$(C_7H_{14}N^+)_4$ $(HPO_4^{2-})_2$**| [**$Al_{24}P_{24}O_{96}$**]-AWW**
$C_7H_{13}N$ = quinuclidine
tetragonal, P4/ncc, a = 13.628Å, c = 15.463Å [(1)]
(Relationship to unit cell of Framework Type: a'= a, b' = b, c' = 2c)

Framework density: 16.7 T/1000Å^3

Channels: [001] **8** 3.9 x 3.9*



8-ring viewed along [001]



framework viewed along [010]

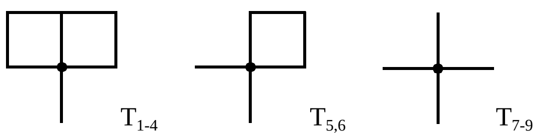
Idealized cell constants: tetragonal, P4$_1$22, a = 12.6Å, c = 26.2Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	19	32	51	77	105	133	167	207	$4\cdot5\cdot4\cdot12_3\cdot5\cdot5$
T_2 (8, 1)	4	10	19	32	51	75	102	133	170	208	$4\cdot5\cdot4\cdot12_6\cdot5\cdot5$
T_3 (8, 1)	4	10	21	32	49	76	109	137	170	207	$4\cdot6\cdot4\cdot12_3\cdot5\cdot5$
T_4 (8, 1)	4	10	21	32	49	74	105	139	173	204	$4\cdot6\cdot4\cdot12_6\cdot5\cdot5$
T_5 (8, 1)	4	11	18	29	48	80	107	133	160	203	$4\cdot5_2\cdot5\cdot5\cdot5\cdot6$
T_6 (8, 1)	4	11	18	29	48	77	106	134	160	204	$4\cdot5_2\cdot5\cdot5\cdot5\cdot6$
T_7 (8, 1)	4	12	18	31	51	76	109	133	164	210	$5\cdot5\cdot5\cdot6\cdot5_2\cdot12_5$
T_8 (4, 2)	4	12	19	32	48	75	112	134	164	206	$5\cdot5\cdot5_2\cdot12_7\cdot6\cdot6$
T_9 (4, 2)	4	12	17	30	54	77	106	134	160	212	$5\cdot5\cdot5\cdot5\cdot5_2\cdot12_3$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:

*Beta [1,2]
[B-Si-O**]-*BEA**[3,4]
[Ga-Si-O**]-*BEA**[4]
CIT-6[5]
Tschernichite[6]

References:

(1) Higgins, J.B., LaPierre, R.B., Schlenker, J.L., Rohrman, A.C., Wood, J.D., Kerr, G.T. and Rohrbaugh, W.J. *Zeolites*, **8**, 446-452 (1988)

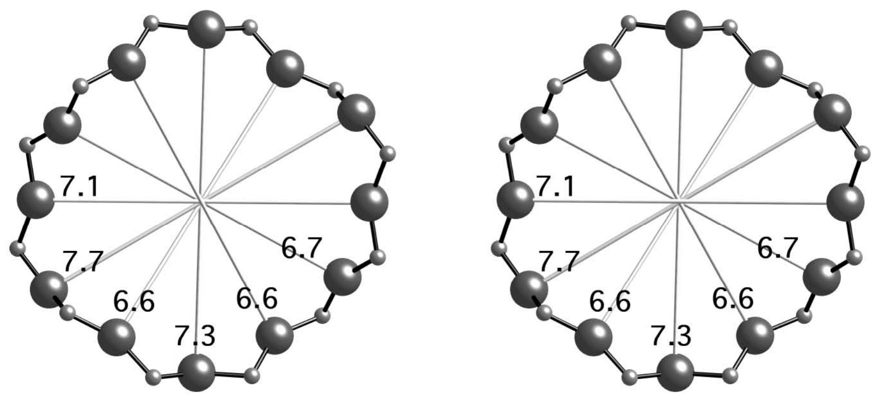
(2) Newsam, J.M., Treacy, M.M.J., Koetsier, W.T. and de Gruyter, C.B. *Proc. R. Soc. Lond. A*, **420**, 375-405 (1988)

(3) Marler, B., Böhme, R. and Gies, H. In *Proc. 9th Int. Zeolite Conf.*, (eds. R. von Ballmoos, J.B. Higgins and M.M.J. Treacy), pp. 425-432 (1993), Butterworth-Heinemann, Boston

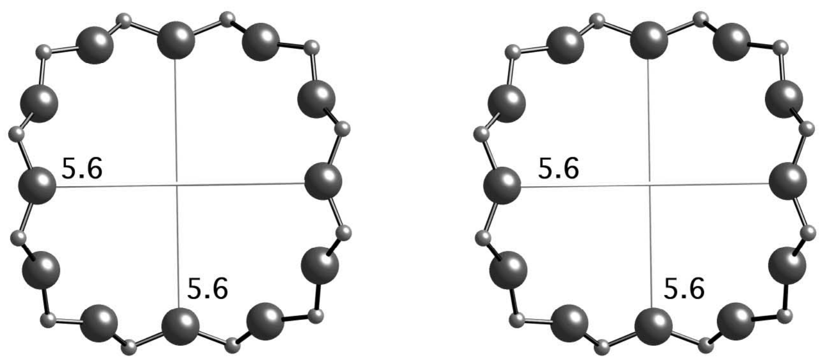
Crystal chemical data: $|Na^{+}_{7}|$ $[Al_7Si_{57}O_{128}]$-***BEA**
tetragonal, $P4_122$, a = 12.661Å, c = 26.406Å [(2)]

Framework density: 15.1 T/1000$Å^3$

Channels: <100> **12** 6.6 x 6.7** ↔ [001] **12** 5.6 x 5.6*



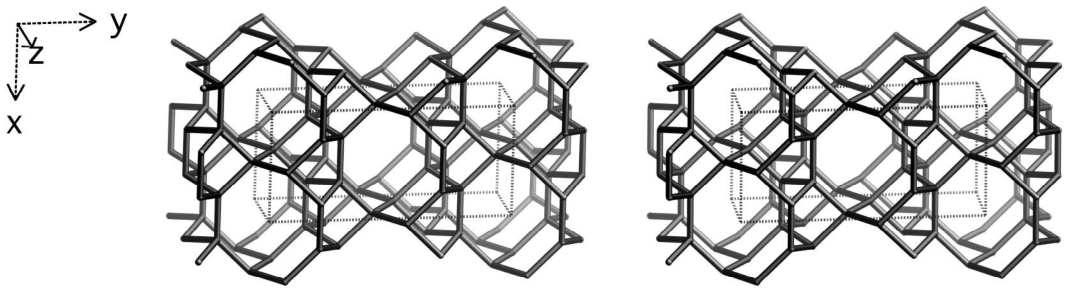
12-ring viewed along <100>



12-ring viewed along [001]

References (cont.):

(4) Reddy, K.S.N., Eapen, M.J., Joshi, P.N., Mirajkar, S.P. and Shiralkar, V.P. *J. Incl. Phenom. Mol. Recogn. Chem.*, **20**, 197-210 (1994)
(5) Takewaki, T., Beck, L.W. and Davis, M.E. *Topics in Catalysis*, **9**, 35-42 (1999)
(6) Boggs, R.C., Howard, D.G., Smith, J.V. and Klein, G.L. *Am. Mineral.*, **78**, 822-826 (1993)



framework viewed along [001]

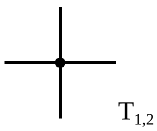
Idealized cell constants: orthorhombic, Cmcm, a = 7.5Å, b = 16.2Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	12	23	43	71	97	128	179	226	264	$5\cdot5\cdot5\cdot5\cdot6\cdot8_2$
T_2 (4, m2m)	4	12	26	42	66	102	140	164	216	288	$5_2\cdot6_2\cdot6\cdot6\cdot6\cdot6$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures:
*Bikitaite[1,2]
|Cs-|[Al-Si-O]-**BIK**[3]
Triclinic bikitaite[4]

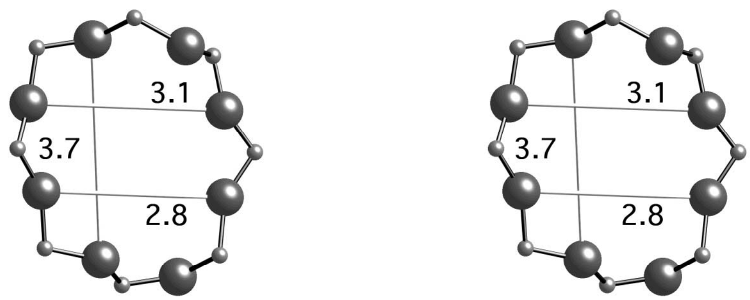
References:

(1) Kocman, V., Gait, R.I. and Rucklidge, J. *Am. Mineral.*, **59**, 71-78 (1974)
(2) Ståhl, K., Kvick, Å. and Ghose, S. *Zeolites*, **9**, 303-311 (1989)
(3) Annehed, H. and Fälth, L. *Z. Kristallogr.*, **166**, 301-306 (1984)
(4) Bissert, G. and Liebau, L. *N. Jb. Miner. Mh.*, 241-252 (1986)

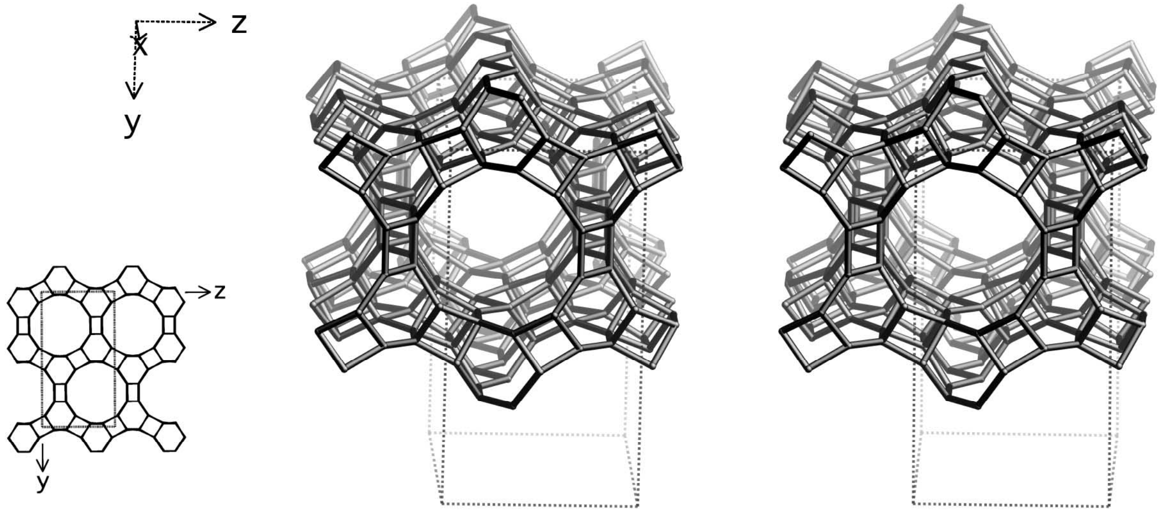
Crystal chemical data: $|Li^+_2 (H_2O)_2|$ **[**$Al_2Si_4 O_{12}$**]-BIK**
triclinic, P1, a = 8.607Å, b = 4.954Å, c = 7.597Å,
α = 89.90°, β = 114.44°, γ = 89.99° (2)
(Relationship to unit cell of Framework Type:
a' = b/2 sin(β), b' = c, c' = a
or, as vectors, **a'** = (**b - a**)/2, **b'** = **c**, **c'** = **a**)

Framework density: 20.3 T/1000Å^3

Channels: [010] **8** 2.8 x 3.7*



8-ring viewed along [010]



framework viewed along [100] (bottom left: projection down [100])

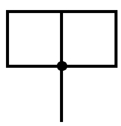
Idealized cell constants: orthorhombic, Imma, a = 20.0Å, b = 23.6Å, c = 12.7Å

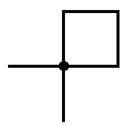
Coordination sequences and vertex symbols:

T_1 (16, 1)	4	10	19	32	51	74	101	129	158	199	$4\cdot5\cdot4\cdot6\cdot5\cdot12_2$
T_2 (16, 1)	4	10	20	32	48	74	104	131	159	195	$4\cdot5\cdot4\cdot6_2\cdot10\cdot12$
T_3 (16, 1)	4	11	19	34	50	71	98	133	162	195	$4\cdot5_2\cdot5\cdot6\cdot5\cdot10_3$
T_4 (16, 1)	4	11	21	32	49	74	101	128	162	200	$4\cdot10_5\cdot5\cdot6_3\cdot5\cdot6_3$
T_5 (16, 1)	4	11	20	31	53	76	97	126	168	199	$4\cdot5\cdot5\cdot6_2\cdot5\cdot10$
T_6 (16, 1)	4	11	18	31	52	75	100	126	158	206	$4\cdot5\cdot5\cdot6\cdot5\cdot6_2$

Secondary building units: 6 or 4

Loop configuration of T-Atoms:


$T_{1,2}$


T_{3-6}

Isotypic framework structures: *Boggsite[1]

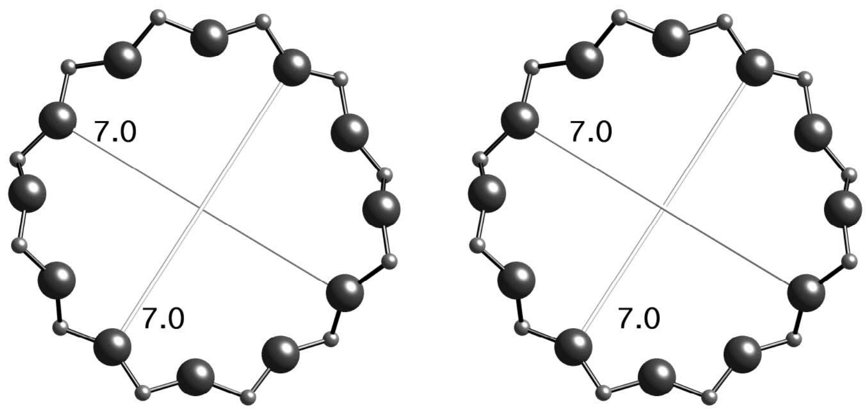
References:

(1) Pluth, J.J. and Smith, J.V. *Am. Mineral.*, **75**, 501-507 (1990)

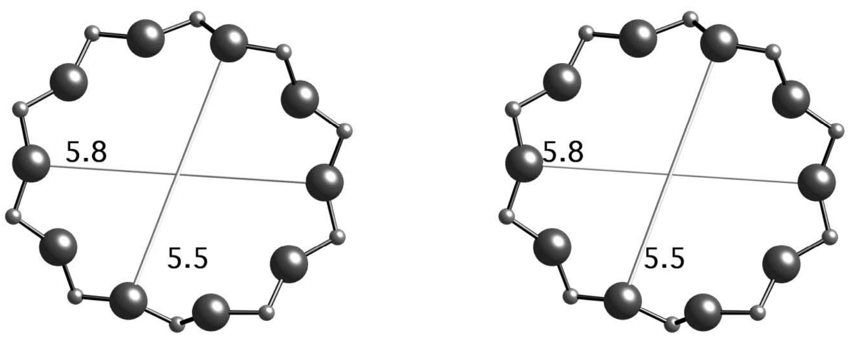
Crystal chemical data: **|**$Ca^{2+}_7Na^+_4\,(H_2O)_{74}$**|** **[**$Al_{18}Si_{78}\,O_{192}$**]-BOG**
orthorhombic, Imma, a = 20.236Å, b = 23.798Å, c = 12.798Å [1]

Framework density: 15.6 T/1000Å^3

Channels: [100] **12** 7.0 x 7.0* ↔ [010] **10** 5.5 x 5.8*

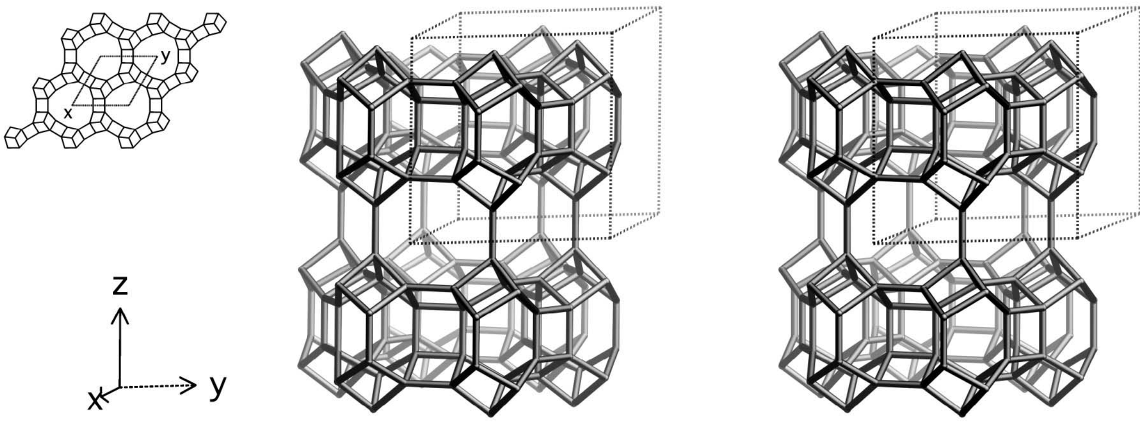


12-ring viewed along [100]



10-ring viewed along [010]

BPH Framework Type $P\bar{6}2m$



framework viewed normal to [001] (top left: projection down [001])

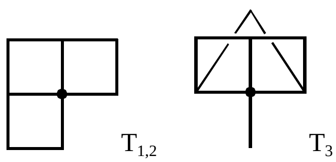
Idealized cell constants: hexagonal, $P\bar{6}2m$, a = 13.1Å, c = 13.0Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	9	17	28	42	60	84	113	140	169	$4\cdot4\cdot4\cdot8_2\cdot6_2\cdot8$
T_2 (12, 1)	4	9	16	25	39	61	86	111	141	173	$4\cdot4\cdot4\cdot6\cdot6\cdot12$
T_3 (4, 3)	4	9	18	30	43	62	85	105	135	180	$4\cdot8\cdot4\cdot8\cdot4\cdot8$

Secondary building units: 6*1

Loop configuration of T-Atoms:



Isotypic framework structures:

*Beryllophosphate-H[1,2]
Linde Q[3]
STA-5[4]

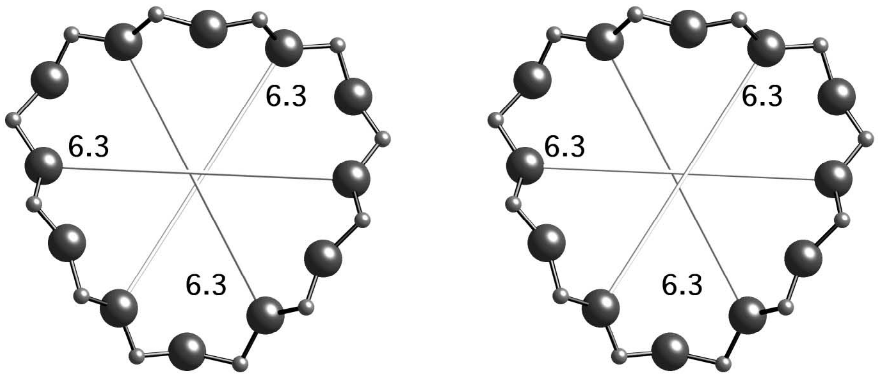
References:

(1) Harvey, G. *Z. Kristallogr.*, **182**, 123-124 (1988)
(2) Harvey, G., Baerlocher, Ch. and Wroblewski, T. *Z. Kristallogr.*, **201**, 113-123 (1992)
(3) Andries, K.J., Bosmans, H.J. and Grobet, P.J. *Zeolites*, **11**, 124-131 (1991)
(4) Patinec, V., Wright, P.A., Aitken, R.A., Lightfoot, P., Purdie, S.D.J., Cox, P.A., Kvick, A. and Vaughan, G. *Chem. Mater.*, **11**, 2456-2462 (1999)

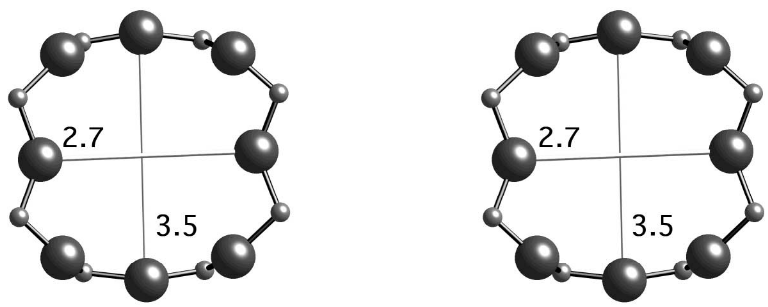
Crystal chemical data: $|K^+_7 Na^+_7 (H_2O)_{20}|$ **[**$Be_{14}P_{14} O_{56}$**]-BPH**
trigonal, P321, a = 12.582Å, c = 12.451Å [(2)]

Framework density: 16.4 T/1000Å^3

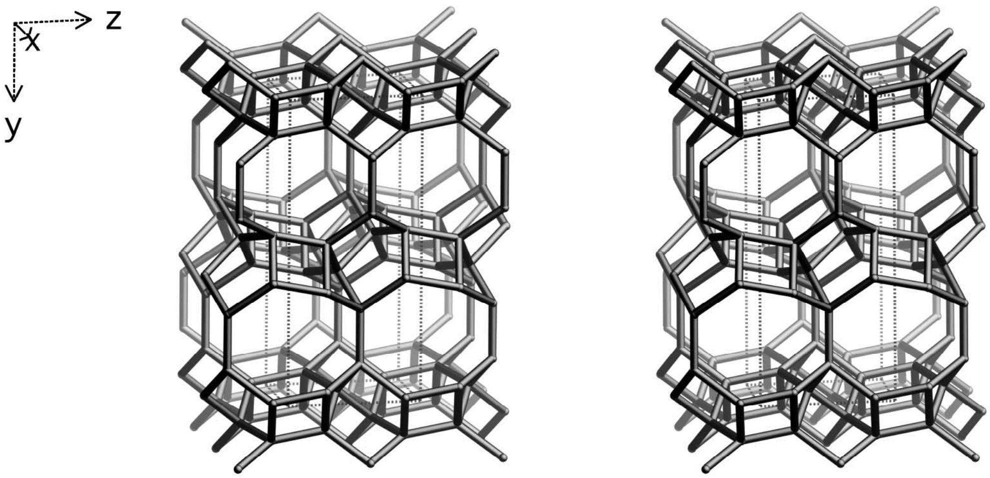
Channels: [001] **12** 6.3 x 6.3* ↔ ⊥ [001] **8** 2.7 x 3.5**



12-ring viewed along [001]



8-ring viewed normal to [001]



framework viewed along [100]

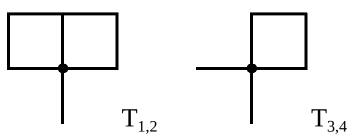
Idealized cell constants: monoclinic, $P2_1/m$, a = 6.8Å, b = 17.1Å, c = 7.6Å, β = 95.8°

Coordination sequences and vertex symbols:

T_1 (4, 1)	4	10	20	37	61	83	110	144	192	238	4·5·4·6·5·8
T_2 (4, 1)	4	10	20	36	61	85	107	147	191	234	4·5·4·8·5·6
T_3 (4, 1)	4	11	23	37	54	82	119	152	184	233	$4\cdot8\cdot5\cdot8\cdot5\cdot8_2$
T_4 (4, 1)	4	11	18	37	62	85	110	147	195	236	$4\cdot5_2\cdot5\cdot6\cdot5\cdot8$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*Brewsterite[1,2]
Ba-dominant brewsterite[3]
CIT-4[4]
Synthetic brewsterite[5]

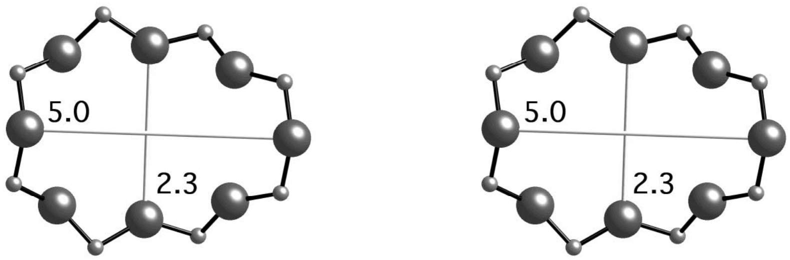
References:

(1) Perrotta, A.J. and Smith, J.V. *Acta Crystallogr.*, **17**, 857-862 (1964)
(2) Schlenker, J.L., Pluth, J.J. and Smith, J.V. *Acta Crystallogr.*, **B33**, 2907-2910 (1977)
(3) Cabella, R., Lucchetti, G., Palenzona, A., Quartieri, S. and Vezzalini, G. *Eur. J. Mineral.*, **5**, 353-360 (1993)
(4) Khodabandeh, S., Lee, G. and Davis, M.E. *Microporous and Mesoporous Materials*, **11**, 87-95 (1997)
(5) Ghobarkar, H. and Schaef, O. *German Patent AZ 198 24 184.4-41* (1999)

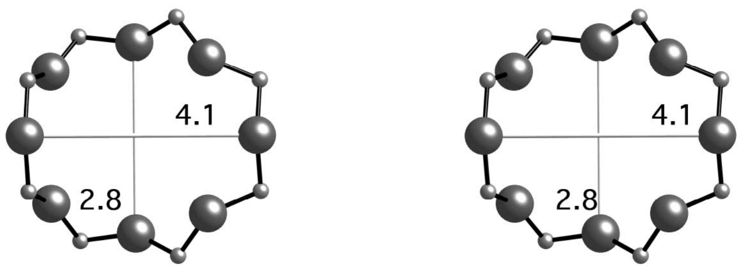
Crystal chemical data: |$(Ba^{2+},Sr^{2+})_2$ $(H_2O)_{10}$| [Al_4Si_{12} O_{32}]-**BRE**
monoclinic, $P12_1/m1$
a = 6.793Å, b = 17.573Å, c = 7.759Å, β = 94.54° (2)

Framework density: 17.3 T/1000$Å^3$

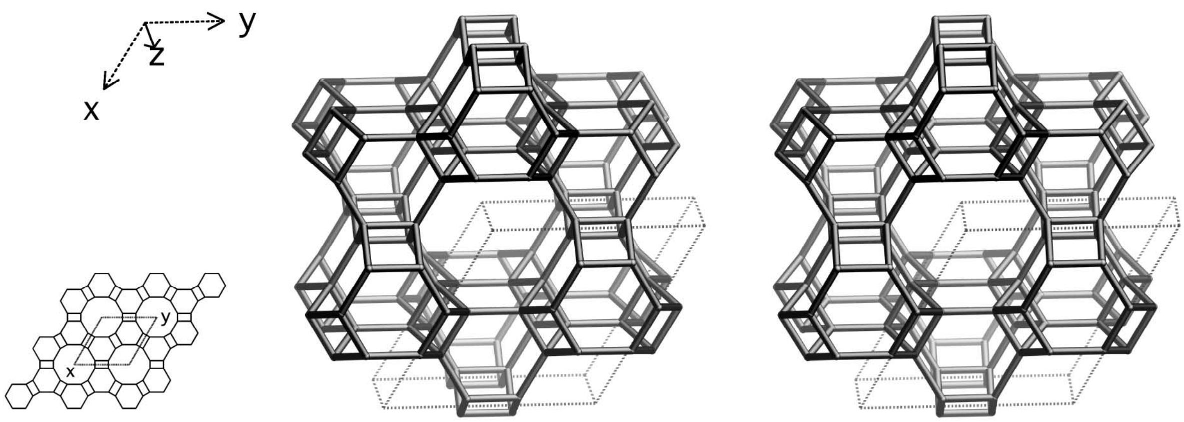
Channels: [100] **8** 2.3 x 5.0* ↔ [001] **8** 2.8 x 4.1*



8-ring viewed along [100]



8-ring viewed along [001]



framework viewed along [001] (bottom left: projection down [001])

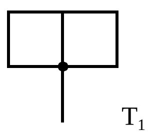
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 12.5Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (12, m)	4	10	20	34	54	78	104	134	168	210	4·6·4·6·6·6

Secondary building units: 4-2 or 6 or 4

Loop configuration of T-Atoms:



Framework description: AB sequence of 6-rings

Isotypic framework structures:

*Cancrinite[1,2]
[Al-Ge-O**]-CAN**[3]
[Ga-Si-O**]-CAN**[4]
[Zn-P-O**]-CAN**[5]
Basic cancrinite[6,7]
Cancrinite hydrate[8]
Davyne[9]
ECR-5[10]
Microsommite[11]
Synthetic cancrinite[12]
Tiptopite[13]
Vishnevite[14]

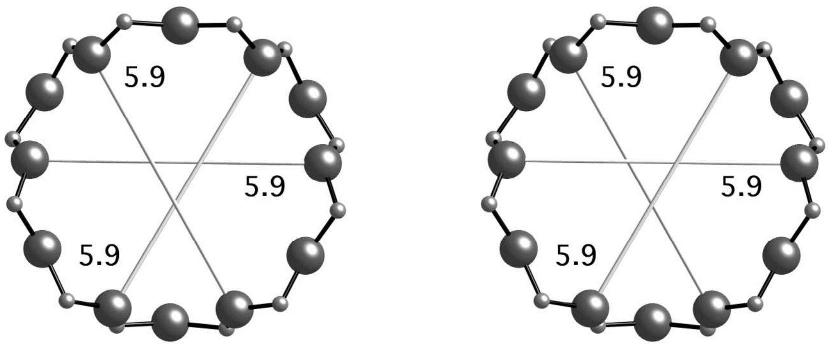
References:

(1) Pauling, L. *Proc. Natl. Acad. Sci.*, **16**, 453-459 (1930)
(2) Jarchow, O. *Z. Kristallogr.*, **122**, 407-422 (1965)
(3) Belokoneva, E.L., Uvarova, T.G. and Dem'yanets, L.N. *Sov. Phys. Crystallogr.*, **31**, 516-519 (1986)
(4) Newsam, J.M. and Jorgensen, J.D. *Zeolites*, **7**, 569-573 (1987)
(5) Yakubovich, O.V., Karimova, O.V. and Mel'nikov, O.K. *Crystallogr. Reports*, **39**, 564-568 (1994)
(6) Barrer, R.M. and White, E.A.D. *J. Chem. Soc.*, 1561-1571 (1952)
(7) Bresciana Pahor, N., Calligaris, M., Nardin, G. and Randaccio, L. *Acta Crystallogr.*, **B38**, 893-895 (1982)
(8) Wyart, J. and Michel-Levy, M. *Compt. Rend.*, **229**, 131- (1949)
(9) Hassan, I. and Grundy, H.D. *Can. Mineral.*, **28**, 341-349 (1990)
(10) Vaughan, D.E.W. *E. Patent A-190,90* (1986)

Crystal chemical data: |Na^{+}_{6} Ca^{2+} CO_3^{2-} $(H_2O)_2$| [Al_6Si_6 O_{24}]-**CAN**
hexagonal, $P6_3$, a = 12.75Å, c = 5.14Å [(2)]

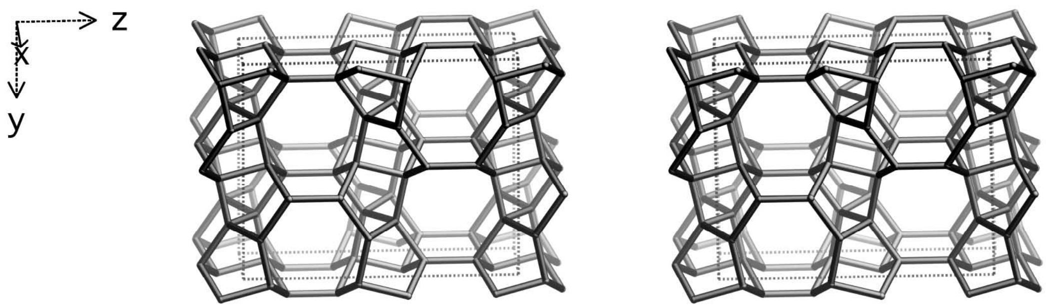
Framework density: 16.6 T/1000Å^3

Channels: [001] **12** 5.9 x 5.9*



12-ring viewed along [001]

References (cont.):
(11) Bonaccorsi, E., Comodi, P. and Merlino, S. *Phys. Chem. Mineral.*, **22**, 367-374 (1995)
(12) Smolin, Y.I., Shepelev, Y.F., Butikova, I.K. and Kobyakov, I.B. *Kristallografiya*, **26**, 63-66 (1981)
(13) Peacor, D.R., Rouse, R.C. and Ahn, J.-H. *Am. Mineral.*, **72**, 816-820 (1987)
(14) Hassan, I. and Grundy, H.D. *Can. Mineral.*, **22**, 333-340 (1984)



framework viewed along [100]

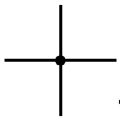
Idealized cell constants: orthorhombic, Cmcm, a = 5.3Å, b = 14.1Å, c = 17.2Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	12	23	41	70	97	125	174	224	264	$5 \cdot 5 \cdot 5 \cdot 5 \cdot 6 \cdot 8_2$
T_2 (8, m)	4	12	26	43	64	101	138	165	215	284	$5 \cdot 6 \cdot 5 \cdot 6 \cdot 6_2 \cdot 8_2$
T_3 (8, m)	4	12	23	43	72	95	128	177	225	259	$5 \cdot 6 \cdot 5 \cdot 6 \cdot 5_2 \cdot 6$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures: *Cesium Aluminosilicate[1]

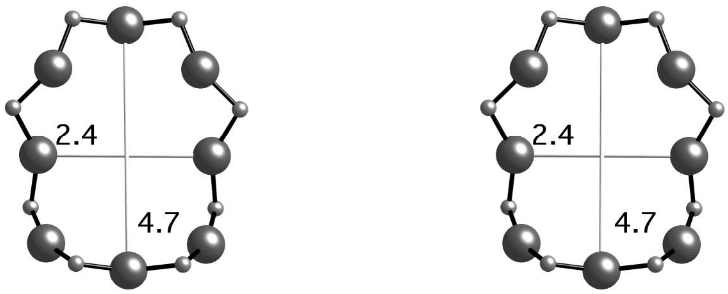
References:

(1) Araki, T. *Z. Kristallogr.*, **152**, 207-213 (1980)

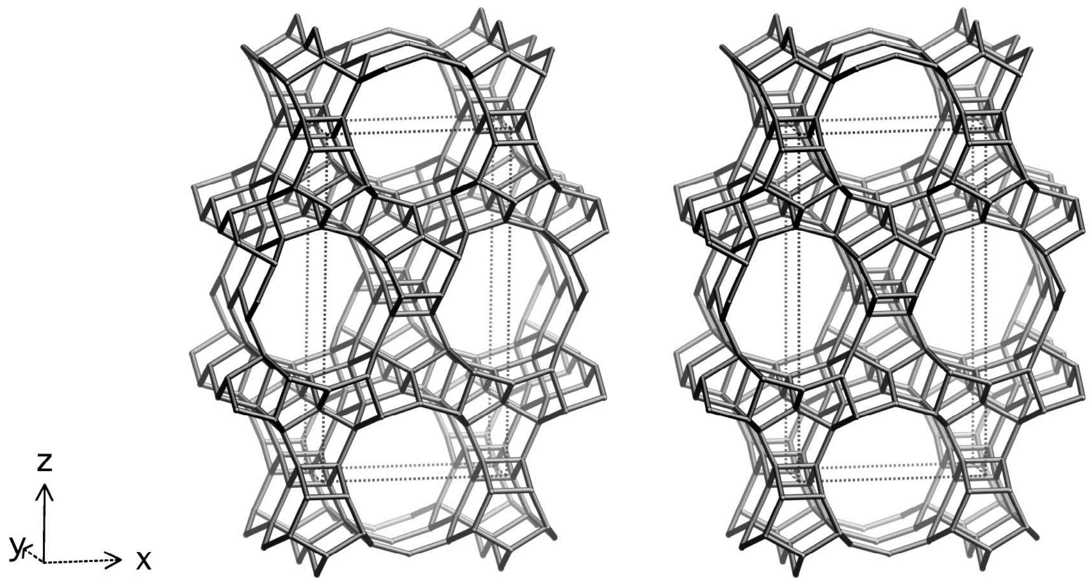
Crystal chemical data: **|**Cs^{+}_{4}**| [**$Al_4Si_{20}O_{48}$**]-CAS**
orthorhombic, Ama2, a = 16.776Å, b = 13.828Å, c = 5.021Å [(1)]
(Relationship to unit cell of Framework Type: **a'** = **-c**, b' = b, c' = a)

Framework density: 20.6 T/1000Å^3

Channels: [001] **8** 2.4 x 4.7*



8-ring viewed along [001]



framework viewed along [010]

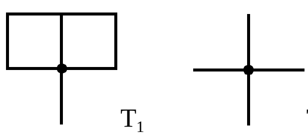
Idealized cell constants: orthorhombic, Imma, a = 14.0Å, b = 5.3Å, c = 26.0Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	10	21	36	56	84	114	143	182	231	4·6·4·6·5·6
T_2 (8, m)	4	12	23	37	55	83	114	153	195	222	$5·6·5·6·5_2·6$
T_3 (8, m)	4	12	22	37	57	84	114	156	184	222	$5·6·5·6·5·6_2$
T_4 (4, mm2)	4	12	24	36	54	79	118	153	190	234	$5·5·5·5·14_{20}·*$
T_5 (4, mm2)	4	12	20	34	56	81	116	151	186	220	$5·5·5·5·5·6_2$

Secondary building units: 5-3

Loop configuration of T-Atoms:



Isotypic framework structures: *CIT-5[1,2]

References:

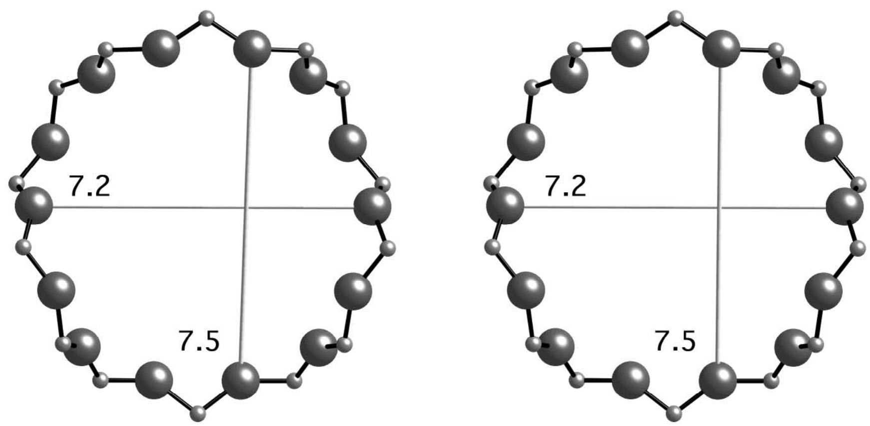
(1) Wagner, P., Yoshikawa, M., Lovallo, M., Tsuji, K., Taspatsis, M. and Davis, M.E. *Chem. Commun.*, 2179-2180 (1997)

(2) Yoshikawa, M., Wagner, P., Lovallo, M., Tsuji, K., Takewaki, T., Chen, C.Y., Beck, L.W., Jones, C., Tsapatsis, M., Zones, S.I. and Davis, M.E. *J. Phys. Chem. B*, **102**, 7139-7147 (1998)

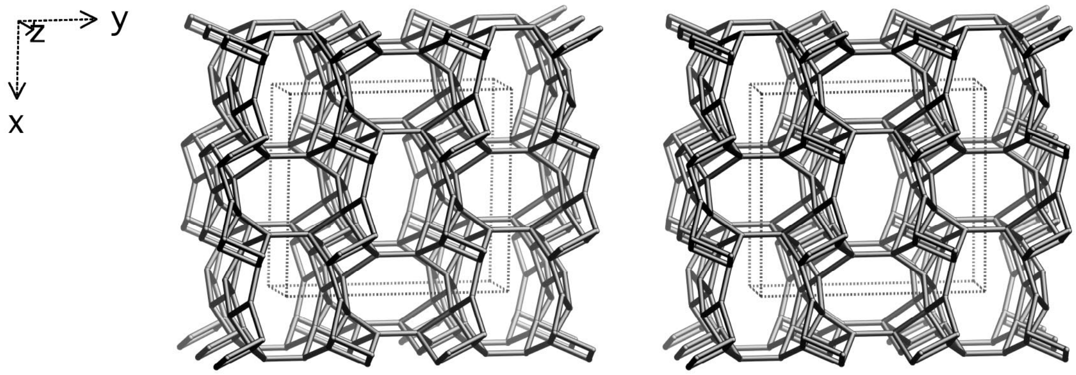
Crystal chemical data: **[**Si_{32} O_{64}**]-CFI**
orthorhombic, $Pmn2_1$, a = 13.674Å, b = 5.022Å, c = 25.488Å [(2)]

Framework density: 18.3 T/1000Å^3

Channels: [010] **14** 7.2 x 7.5*



14-ring viewed along [010]



framework viewed along [001]

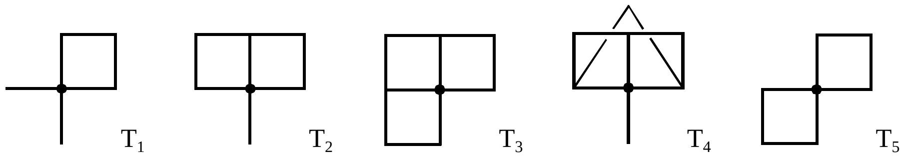
Idealized cell constants: monoclinic, C12/m1, a = 15.5Å, b = 16.9Å, c = 7.3Å, β = 96.1°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	22	34	50	76	111	142	165	199	$4 \cdot 8 \cdot 6_3 \cdot 8 \cdot 6_3 \cdot 8$
T_2 (8, 1)	4	10	19	33	55	79	100	129	172	216	$4 \cdot 6 \cdot 4 \cdot 6_2 \cdot 6 \cdot 6$
T_3 (8, 1)	4	9	18	34	55	76	97	131	177	217	$4 \cdot 4 \cdot 4 \cdot 6 \cdot 6 \cdot 6_2$
T_4 (8, 1)	4	9	18	34	55	75	98	133	177	216	$4 \cdot 6_3 \cdot 4 \cdot 6_3 \cdot 4 \cdot 8$
T_5 (4, 2)	4	10	18	32	58	80	96	124	176	228	$4 \cdot 4 \cdot 6_2 \cdot 6_2 \cdot 10 \cdot 10$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Co-Ga-Phosphate-5[1]

References:

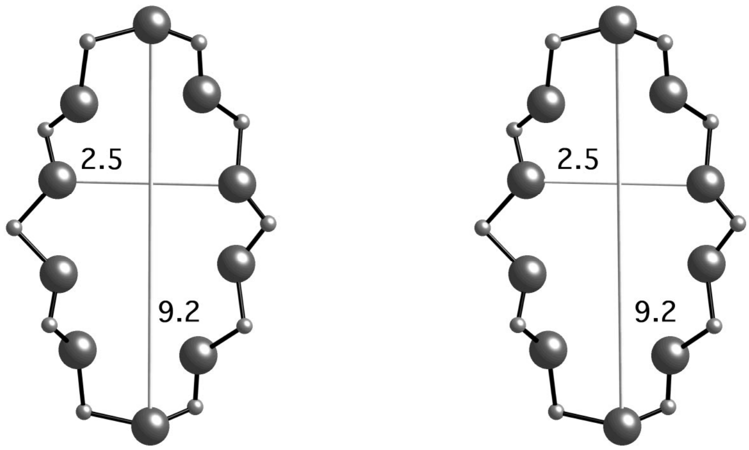
(1) Chippindale, A.M. and Cowley, A.R. *Zeolites*, **18**, 176-181 (1997)

Co-Ga-Phosphate-5 Type Material CGF

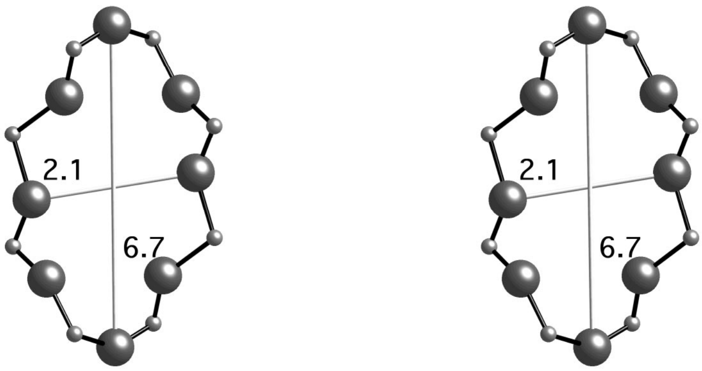
Crystal chemical data: $|(C_6H_{14}N_2^{2+})_2|$**[**$Co_4Ga_5P_9\ O_{36}$**]-CGF**
$C_6H_{12}N_2$ = DABCO
monoclinic, I12/a1
a = 15.002Å, b = 17.688Å, c = 15.751Å, β = 97.24° (1)
(Relationship to unit cell of Framework Type: a' = 2c, b' = b, c' = a)

Framework density: 17.4 T/1000Å^3

Channels: {[100] **10** 2.5 x 9.2* + **8** 2.1 x 6.7*} ↔ [001] **8** 2.4 x 4.8*

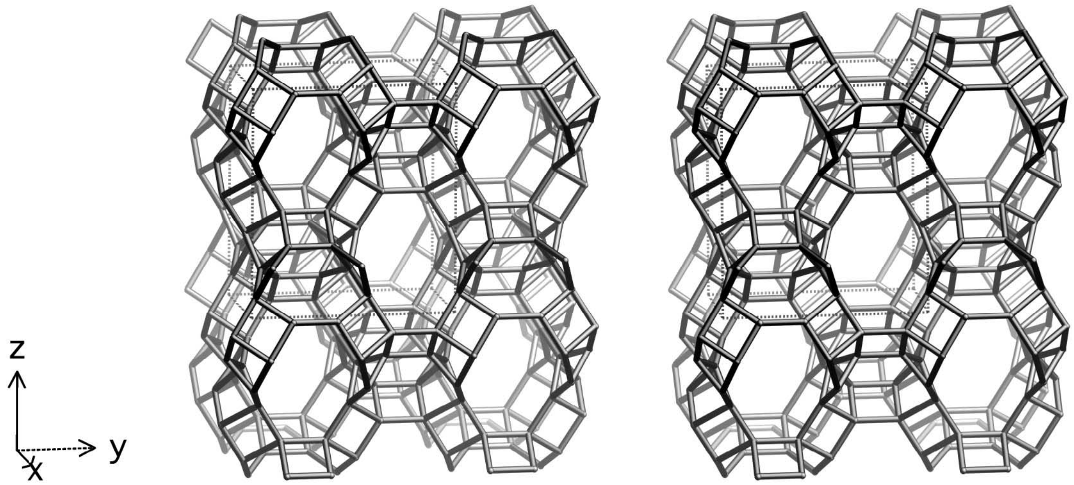


10-ring viewed along [100]



8-ring viewed along [100]

See Appendix A for 8-ring viewed along [001]



framework viewed along [100]

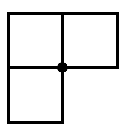
Idealized cell constants: orthorhombic, Pnma, a = 8.4Å, b = 14.1Å, c = 15.9Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	16	26	43	67	91	116	148	188	4·4·4·6·6·8
T_2 (8, 1)	4	9	18	32	48	66	91	121	150	184	$4\cdot4\cdot4\cdot10_2\cdot8\cdot8_6$
T_3 (8, 1)	4	9	17	28	45	66	91	119	148	186	$4\cdot4\cdot4\cdot8_2\cdot6\cdot10$
T_4 (8, 1)	4	9	18	32	48	67	91	119	151	185	$4\cdot4\cdot4\cdot8\cdot8_4\cdot10$

Secondary building units: 4

Loop configuration of T-Atoms:



$T_{1\text{-}4}$

Isotypic framework structures:

*Co-Ga-Phosphate-6[1]
[Zn-Ga-P-O**]-CGS**[1]
TNU-1, **[**Ga-Si-O**]-CGS**[2]
TsG-1, **[**Ga-Si-O**]-CGS**[3]

References:

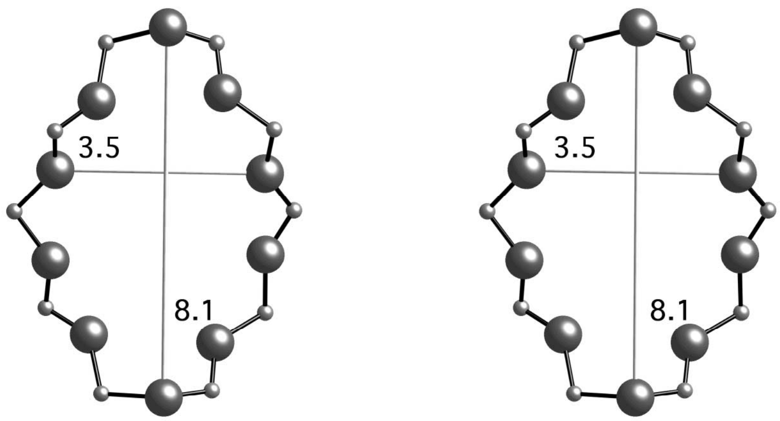
(1) Cowley, A.R. and Chippindale, A.M. *Microporous and Mesoporous Materials*, **28**, 163-172 (1999)
(2) Hong, S.B., Kim, S.H., Kim, Y.G., Kim, Y.C., Barrett, P.A. and Camblor, M.A. *J. Mater. Chem.*, **9**, 2287-2289 (1999)
(3) Lee, Y.J., Kim, S.J., Wu, G. and Parise, J.B. *Chem. Mater.*, **11**, 879-880 (1999)

Co-Ga-Phosphate-6 Type Material CGS

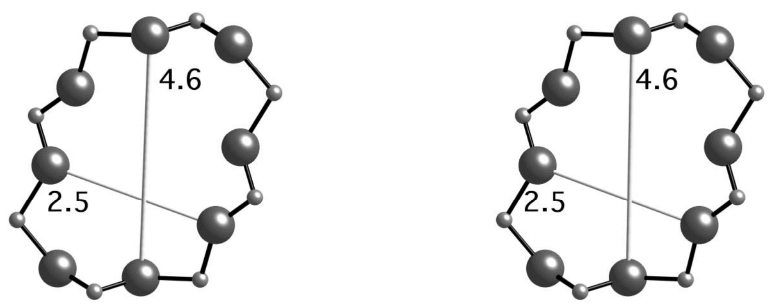
Crystal chemical data: $|(C_7H_{14}N^+)_4|$ $[Co_4Ga_{12}P_{16}O_{64}]$**-CGS**
$C_7H_{13}N$ = quinuclidine
monoclinic, $P12_1/c1$
a = 14.365Å, b = 16.305Å, c = 8.734Å, β = 90.24° [(1)]
(Relationship to unit cell of Framework Type: a' = b, b' = c, c' = a)

Framework density: 15.6 T/1000Å^3

Channels: {[001] **10** 3.5 x 8.1 ↔ [100] **8** 2.5 x 4.6}***

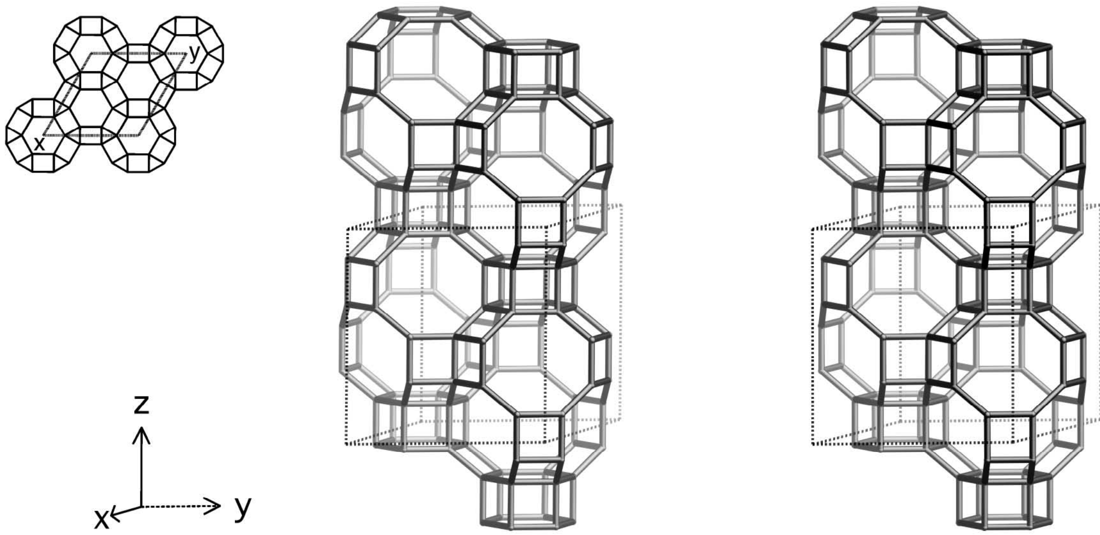


10-ring viewed along [001]



8-ring viewed along [100]

CHA Framework Type $R\bar{3}m$



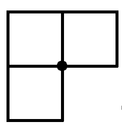
framework viewed normal to [001] (top left: projection down [001])

Idealized cell constants: trigonal, $R\bar{3}m$, a = 13.7Å, c = 14.8Å

Coordination sequences and vertex symbols: T_1 (36, 1) 4 9 17 29 45 64 85 110 140 173 4·4·4·8·6·8

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



T_1

Framework description: AABBCC sequence of 6-rings

Isotypic framework structures:

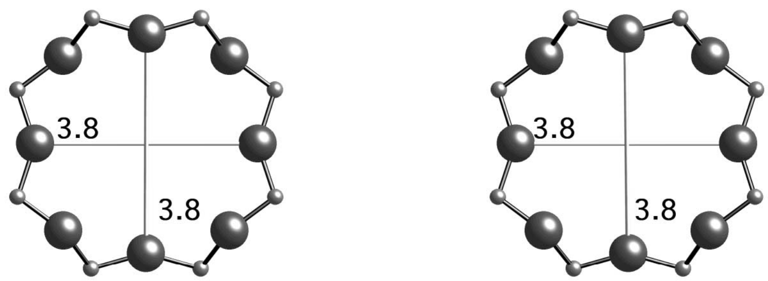
*Chabazite[1,2]
[Al-Co-P-O**]-CHA**[3]
[Co-Al-P-O**]-CHA**[3,4]
[Mg-Al-P-O**]-CHA**[4]
AlPO-34[5]
CoAPO-44[6]
CoAPO-47[6]
Dehydrated Na-Chabazite[7]
GaPO-34[8]
LZ-218[9]
Linde D[10,11]
Linde R[12]
MeAPO-47[6,13,14]
MeAPSO-47[6,13,14]
Phi[11,15]
SAPO-34[16]
SAPO-47[17]
Si-CHA[18]
Willhendersonite[19]
ZK-14[20,21]
ZYT-6[22]

Alternate designation: Herschelite (discredited)

Crystal chemical data: $|Ca^{2+}_6 (H_2O)_{40}|$ **[**$Al_{12}Si_{24} O_{72}$**]-CHA**
rhombohedral, $R\bar{3}m$, a = 9.42Å, α = 94.47° (2)

Framework density: 14.5 T/1000Å^3

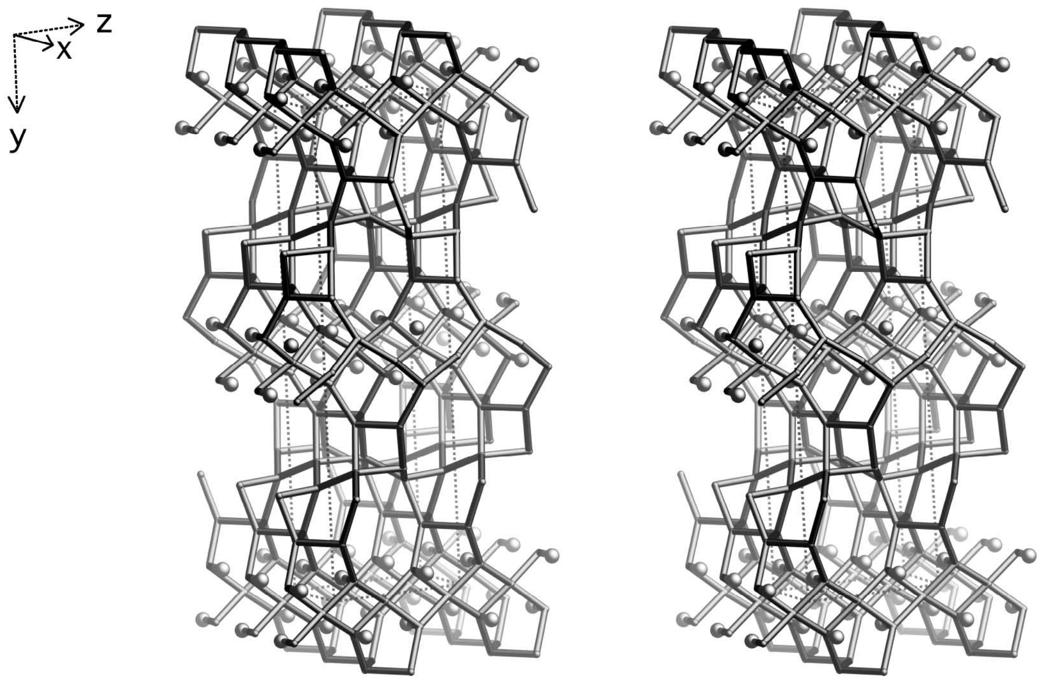
Channels: ⊥ [001] **8** 3.8 x 3.8*** (variable due to considerable flexibility of framework)



8-ring viewed normal to [001]

References:

(1) Dent, L.S. and Smith, J.V. *Nature*, **181**, 1794-1796 (1958)
(2) Smith, J.V., Rinaldi, R. and Dent Glasser, L.S. *Acta Crystallogr.*, **16**, 45-53 (1963)
(3) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(4) Feng, P., Bu, X., Gier, T.E. and Stucky, G.D. *Microporous and Mesoporous Materials*, **23**, 221-229 (1998)
(5) Harding, M.M. and Kariuki, B.M. *Acta Crystallogr.*, **C50**, 852-854 (1994)
(6) Bennett, J.M. and Marcus, B.K. *Stud. Surf. Sci. Catal.*, **37**, 269-279 (1988)
(7) Mortier, W.J., Pluth, J.J. and Smith, J.V. *Mater. Res. Bull.*, **12**, 241-250 (1977)
(8) Schott-Darie, C., Kessler, H., Soulard, M., Gramlich, V. and Benazzi, E. *Stud. Surf. Sci. Catal.*, **84**, 101-108 (1994)
(9) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,333,859* (1982)
(10) Breck, D.W. and Acara, N.A. *U.S. Patent 2,950,952* (1960)
(11) Lillerud, K.P., Szostak, R. and Long, A. *J. Chem. Soc., Faraday Trans.*, **90**, 1547-1551 (1994)
(12) Milton, R.M. *Brit. Patent 841,812* (1960)
(13) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)
(14) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo
(15) Grose, R.W. and Flanigen, E.M. *U.S. Patent 4,124,686* (1978)
(16) Lok, B.M., Messina, C.A., Patton, R.L., Gajek, R.T., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **106**, 6092-6093 (1984)
(17) Pluth, J.J. and Smith, J.V. *J. Phys. Chem.*, **93**, 6516-6520 (1989)
(18) Díaz-Cabañas, M.J., Barrett, P.A. and Camblor, M.A. *Chem. Commun.*, 1881-1882 (1998)
(19) Tillmanns, E., Fischer, R.X. and Baur, W.H. *N. Jb. Miner. Mh.*, 547-558 (1984)
(20) Kuehl, G.H. *private communication*
(21) Kuehl, G.H. In *Molecular Sieves*, (ed. R.M. Barrer), pp. 85-91 (1968), Soc. Chem. Indus., London
(22) Ito, M., Shimoyama, Y., Saito, Y., Tsurita, Y. and Otake, M. *Acta Crystallogr.*, **C41**, 1698-1700 (1985)



framework viewed along [100]

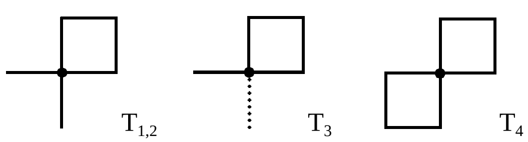
Idealized cell constants: orthorhombic, Pbcn, a = 5.0Å, b = 31.2Å, c = 9.0Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	22	40	64	89	120	160	203	248	$4\cdot6_3\cdot6\cdot6\cdot6_2\cdot6_2$
T_2 (8, 1)	4	10	20	36	60	86	115	157	196	238	$4\cdot5\cdot6\cdot9\cdot6_3\cdot10_2$
T_3 (8, 1)	3	8	13	29	53	80	113	147	193	231	4·5·9
T_4 (4, 2)	4	6	14	28	56	80	114	152	190	236	4·4·5·9·10·10

Secondary building units: 5-2

Loop configuration of T-Atoms:



Isotypic framework structures: *Chiavennite[1]

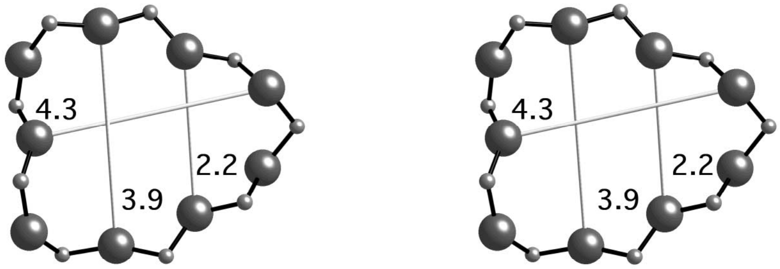
References:

(1) Tazzoli, V., Domeneghetti, M.C., Mazzi, F. and Cannillo, E. *Eur. J. Mineral.*, **7**, 1339-1344 (1995)

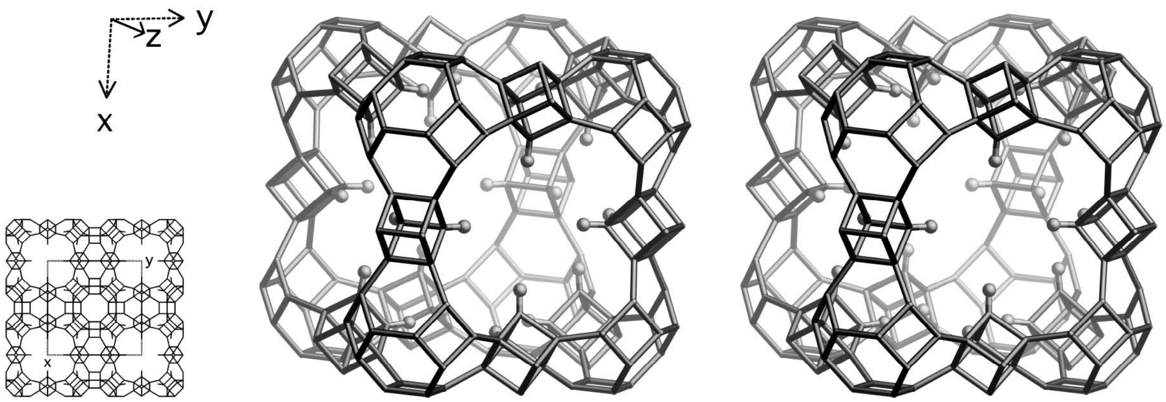
Crystal chemical data: |Ca^{2+}_4 Mn^{2+}_4 $(H_2O)_8$| [Be_8Si_{20} $O_{52}(OH)_8$]- **-CHI**
orthorhombic, Pnab, a = 8.729Å, b = 31.326Å, c = 4.903Å [(1)]
(Relationship to unit cell of Framework Type: **a'** = **-c**, b' = b, c' = a)

Framework density: 20.9 T/1000Å^3

Channels: [001] **9** 3.9 x 4.3*



9-ring viewed along [001]



framework viewed along [001] (bottom left: projection down [001])

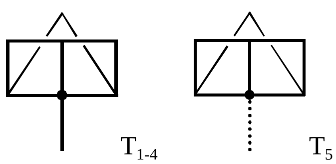
Idealized cell constants: cubic, $Pm\bar{3}m$, a = 25.8Å

Coordination sequences and vertex symbols:

T_1 (48, 1)	4	9	16	23	31	44	59	74	91	109	4·6·4·6·4·12
T_2 (48, 1)	4	9	17	27	37	47	56	66	80	99	4·6·4·6·4·8
T_3 (48, 1)	4	8	13	22	34	44	55	72	94	117	4·6·4·6·4·20_8
T_4 (24, m)	4	9	16	23	32	45	58	76	98	118	4·6·4·6·4·8
T_5 (24, m)	3	5	10	18	29	45	56	65	86	110	4··4··4··

Secondary building units: 4-4 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Cloverite[1]

References:

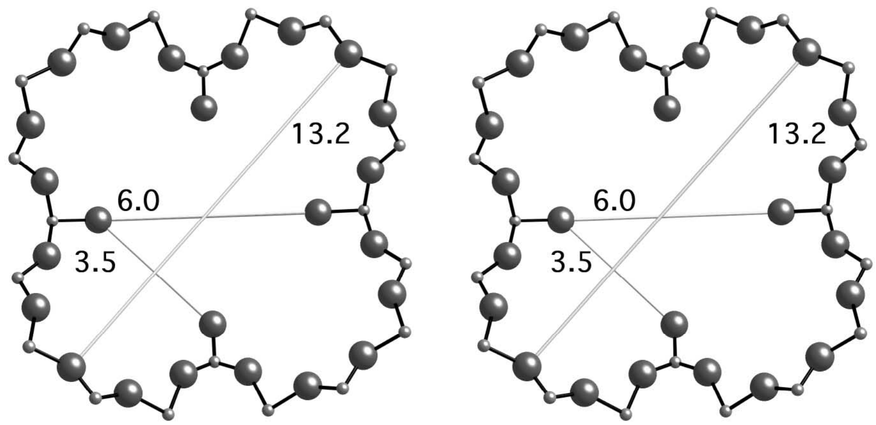
(1) Estermann, M., McCusker, L.B., Baerlocher, Ch., Merrouche, A. and Kessler, H. *Nature*, **352**, 320-323 (1991)

Cloverite Type Material -CLO

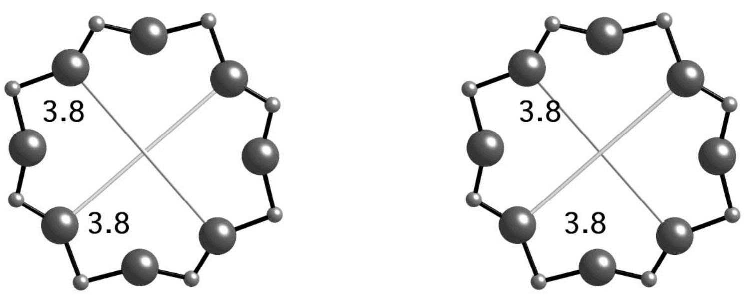
Crystal chemical data: **|**$(C_7H_{14}N^+)_{24}$**|**$_8$ **[**$F_{24}\,Ga_{96}P_{96}\,O_{372}(OH)_{24}$**]**$_8$- **-CLO**
$C_7H_{13}N$ = quinuclidine
cubic, $Fm\bar{3}c$, a = 51.712Å [1]
(Relationship to unit cell of Framework Type: a' = 2a)

Framework density: 11.1 T/1000$Å^3$

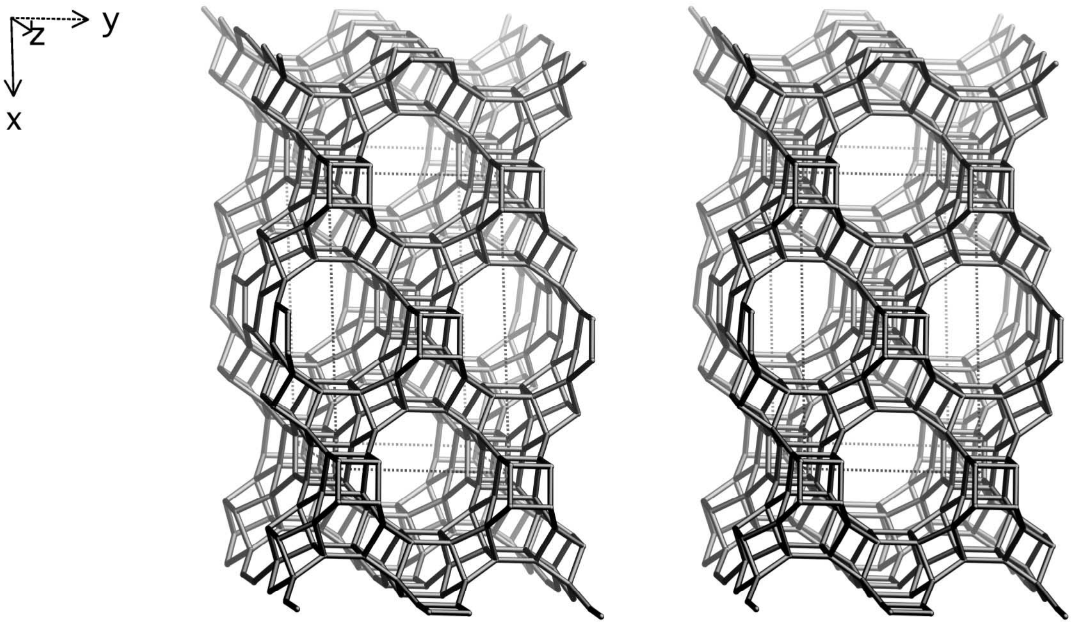
Channels: <100> **20** 4.0 x 13.2*** | <100> **8** 3.8 x 3.8***



20-ring viewed along <100>



8-ring viewed along <100>



framework viewed along [001]

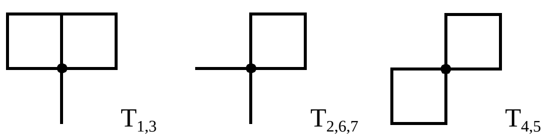
Idealized cell constants: monoclinic, C2/m, a = 22.7Å, b = 13.4Å, c = 12.6Å, β = 69.5°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	19	32	50	73	101	132	164	199	$4\cdot5\cdot4\cdot10_4\cdot5\cdot6_2$
T_2 (8, 1)	4	11	18	31	52	77	98	126	164	205	$4\cdot5\cdot5\cdot6\cdot5\cdot10_2$
T_3 (8, 1)	4	10	21	32	47	74	105	134	159	196	$4\cdot6\cdot4\cdot10_4\cdot5\cdot6_2$
T_4 (8, 1)	4	10	19	32	51	74	100	130	165	203	$4\cdot4\cdot5\cdot6_2\cdot5\cdot12_7$
T_5 (8, 1)	4	10	19	32	51	74	101	130	164	203	$4\cdot4\cdot5\cdot6_2\cdot5\cdot12_4$
T_6 (8, 1)	4	11	18	28	49	77	103	126	155	201	$4\cdot5_2\cdot5\cdot6_2\cdot6\cdot6_2$
T_7 (8, 1)	4	11	19	32	49	75	105	131	159	196	$4\cdot6_2\cdot5\cdot6\cdot5\cdot10_2$

Secondary building units: 5-2

Loop configuration of T-Atoms:



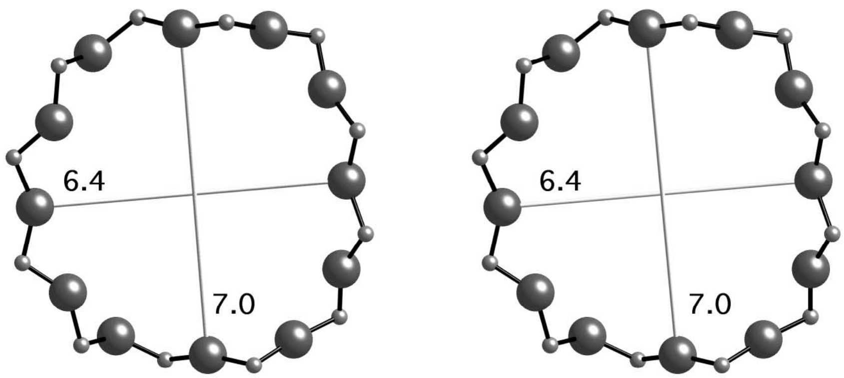
Isotypic framework structures:
*CIT-1[1]
SSZ-26 (contains major structural units of **CON**)[1,2]
SSZ-33 (contains major structural units of **CON**)[1,2]

(1) Lobo, R.F. and Davis, M.E. *J. Am. Chem. Soc.*, **117**, 3764-3779 (1995)
(2) Lobo, R.F., Pan, M., Chan, I., Li, H.X., Medrud, R.C., Zones, S.I., Crozier, P.A. and Davis, M.E. *Science*, **262**, 1543-1546 (1993)

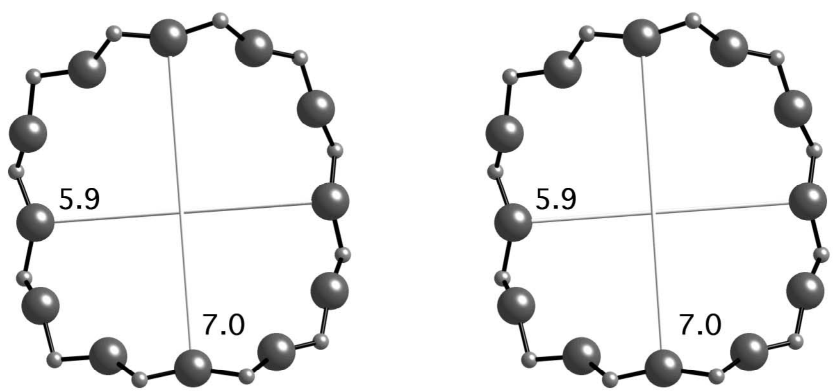
Crystal chemical data: $|H^+_2|$ **[**$B_2Si_{54}O_{112}$**]-CON**
monoclinic, C12/m1
a = 22.624Å, b = 13.350Å, c = 12.364Å, β = 68.91° (1)

Framework density: 16.1 T/1000Å^3

Channels: [001] **12** 6.4 x 7.0* ↔ [100] **12** 7.0 x 5.9* ↔[010] **10** 5.1 x 4.5*

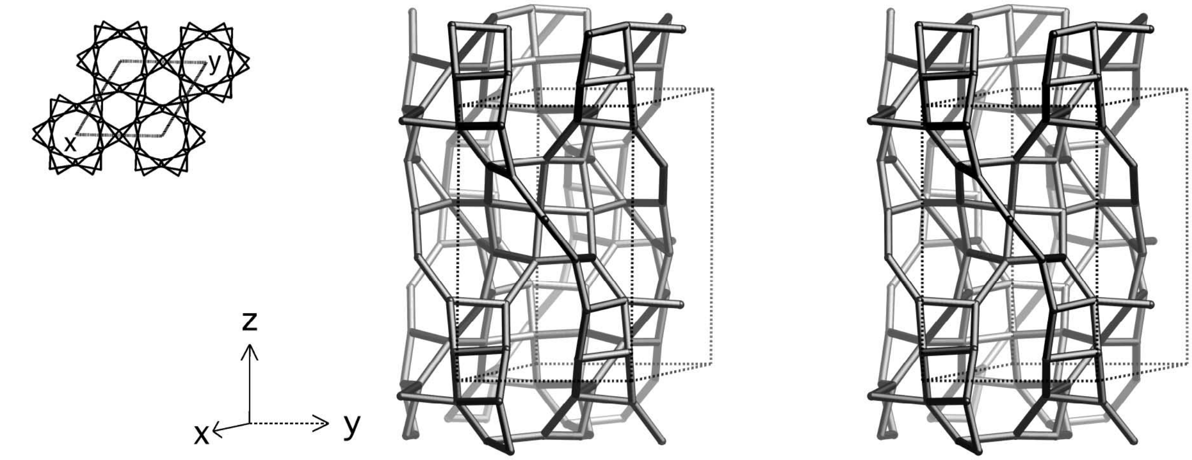


12-ring viewed along [001]



12-ring viewed along [100]

See Appendix A for 10-ring viewed along [010]



framework viewed normal to [001] (top left: projection down [001])

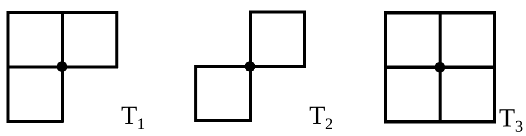
Idealized cell constants: hexagonal, $P6_122$, a = 9.4Å, c = 15.3Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	9	18	32	54	83	113	149	191	234	$4\cdot4\cdot4\cdot8_8\cdot8\cdot8$
T_2 (6, 2)	4	10	20	33	56	85	114	144	192	242	$4\cdot4\cdot8_3\cdot8_3\cdot8_6\cdot8_6$
T_3 (6, 2)	4	8	16	33	52	73	112	160	190	214	$4\cdot4\cdot4\cdot4\cdot8\cdot8$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Chiral Zincophosphate[1,2]

References:

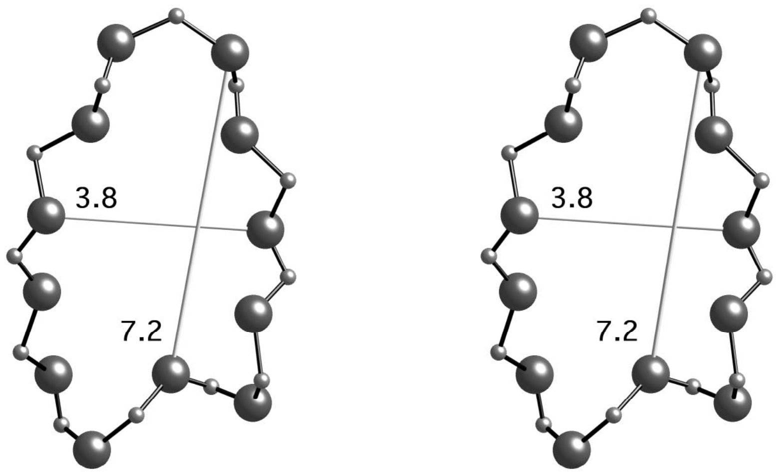
(1) Rajic, N., Logar, N.Z. and Kaucic, V. *Zeolites*, **15**, 672-678 (1995)

(2) Harrison, W.T.A., Gier, T.E., Stucky, G.D., Broach, R.W. and Bedard, R.A. *Chem. Mater.*, **8**, 145-151 (1996)

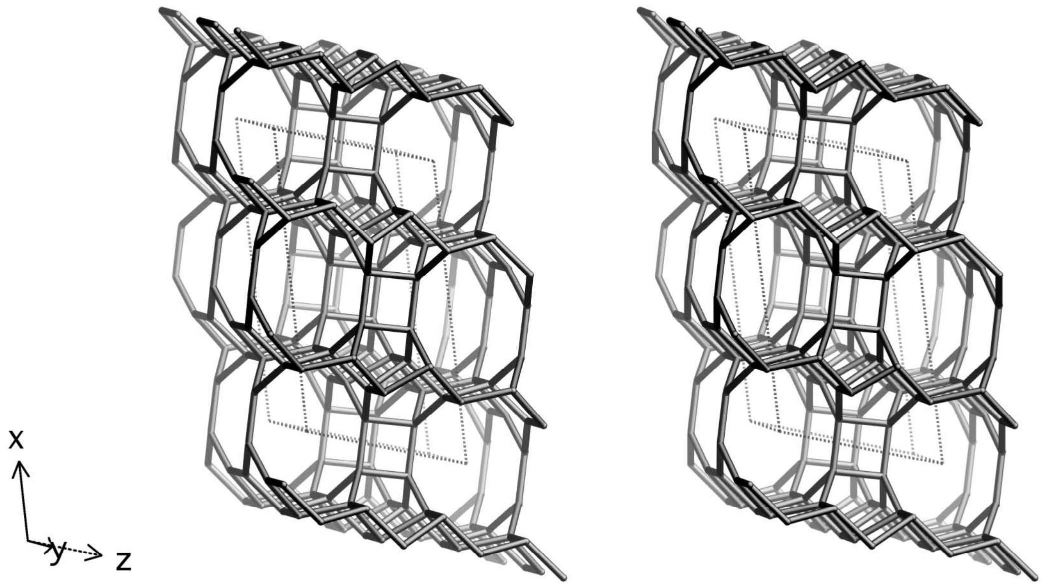
Crystal chemical data: |Na^+_{12} $(H_2O)_{12}$| **[**$Zn_{12}P_{12}$ O_{48}**]-CZP**
hexagonal, $P6_122$, a = 10.480Å, c = 15.089Å (2)

Framework density: 16.7 T/1000Å^3

Channels: [001] **12** 3.8 x 7.2* (highly distorted 12-ring)



distorted 12-ring viewed along [001]



framework viewed along [001]

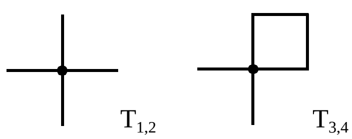
Idealized cell constants: monoclinic, C2/m, a = 18.6Å, b = 7.5Å, c = 10.4Å, β = 108.9°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	12	22	39	65	91	121	163	208	250	$5\cdot5\cdot5\cdot5_2\cdot8\cdot10_2$
T_2 (8, 1)	4	12	20	37	63	91	118	164	212	245	$5\cdot5\cdot5\cdot5_2\cdot5\cdot8$
T_3 (4, m)	4	11	24	41	59	99	130	155	202	262	$4\cdot5_2\cdot5\cdot8\cdot5\cdot8$
T_4 (4, m)	4	11	24	39	63	95	132	156	199	266	$4\cdot5_2\cdot5\cdot8\cdot5\cdot8$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures: *Dachiardite[1,2]

Alternate designation: Svetlozarite (discredited)[3]

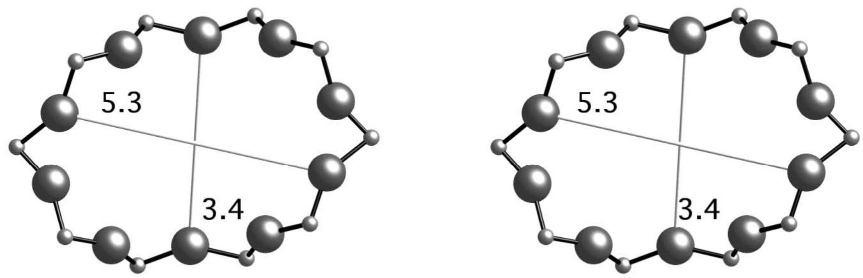
References:

(1) Gottardi, G. and Meier, W.M. *Z. Kristallogr.*, **119**, 53-64 (1963)
(2) Vezzalini, G. *Z. Kristallogr.*, **166**, 63-71 (1984)
(3) Gellens, L.R., Price, G.D. and Smith, J.V. *Mineral. Mag.*, **45**, 157-161 (1982)

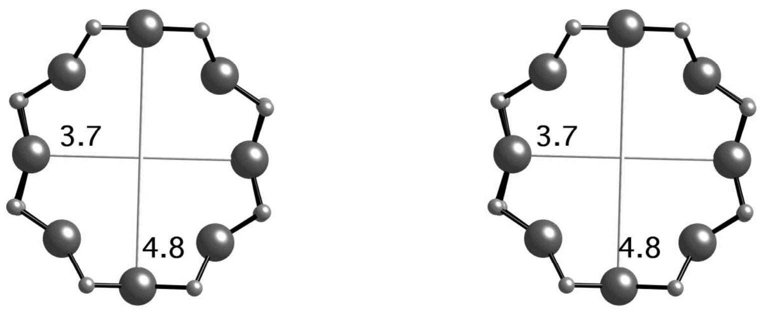
Crystal chemical data: |$(Ca^{2+}_{0.5},K^+,Na^+)_5$ $(H_2O)_{12}$| [Al_5Si_{19} O_{48}]-**DAC**
monoclinic, C12/m1
a = 18.676Å, b = 7.518Å, c = 10.246Å, β = 107.87° (2)

Framework density: 17.5 T/1000$Å^3$

Channels: [010] **10** 3.4 x 5.3* ↔ [001] **8** 3.7 x 4.8*

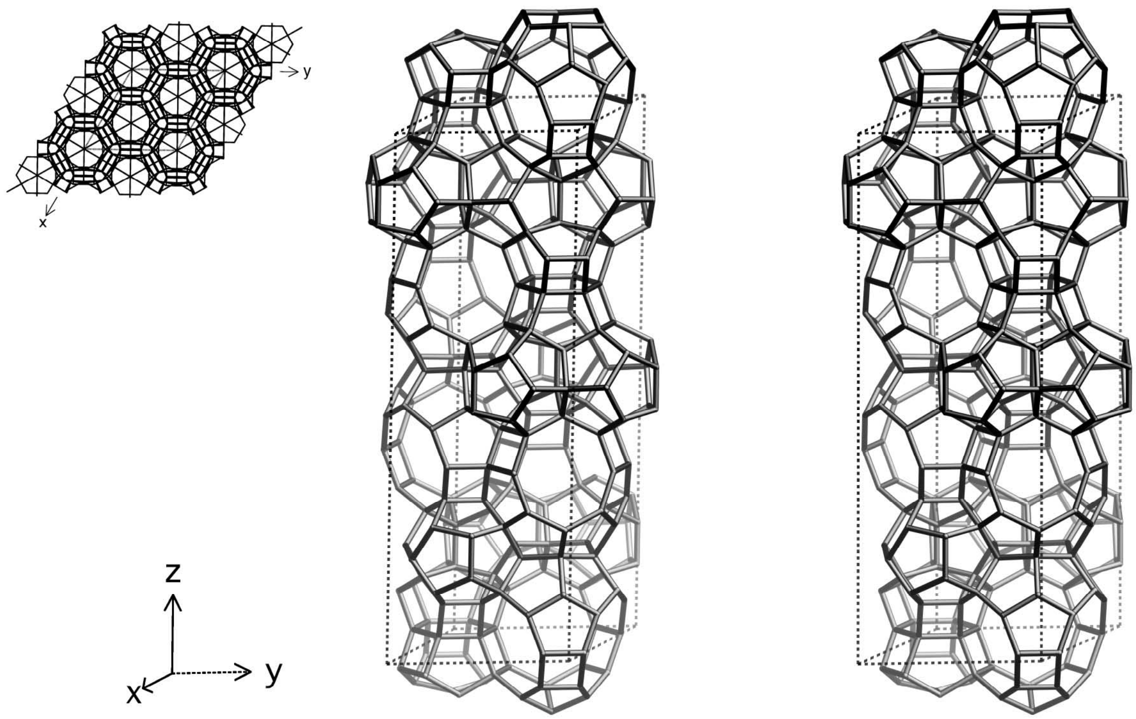


10-ring viewed along [010]



8-ring viewed along [001]

DDR   Framework Type $R\bar{3}m$



framework viewed normal to [001] (top left: projection down [001])

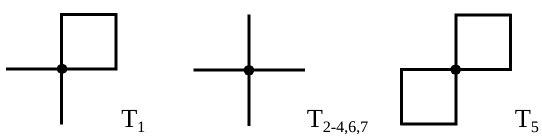
Idealized cell constants: trigonal, $R\bar{3}m$, a = 13.8Å, c = 40.8Å

Coordination sequences and vertex symbols:

T_1 (36, 1)	4	11	23	39	62	91	124	159	203	251	4·5·5·5·5·8
T_2 (18, m)	4	12	22	37	59	93	127	158	193	251	5·5·5·5·5·5
T_3 (18, m)	4	12	25	40	61	86	119	164	212	253	5·5·5·5·5·6
T_4 (18, m)	4	12	24	40	63	87	121	165	208	255	5·5·5·5·5·8
T_5 (18, 2)	4	10	21	37	62	94	124	158	196	252	4·4·5·5·6·8
T_6 (6, 2)	4	12	24	39	57	93	121	157	210	240	5·5·5·5·5·5
T_7 (6, 2)	4	12	24	33	60	97	136	150	192	264	5·5·5·5·5·5

Secondary building units: 5-1

Loop configuration of T-Atoms:



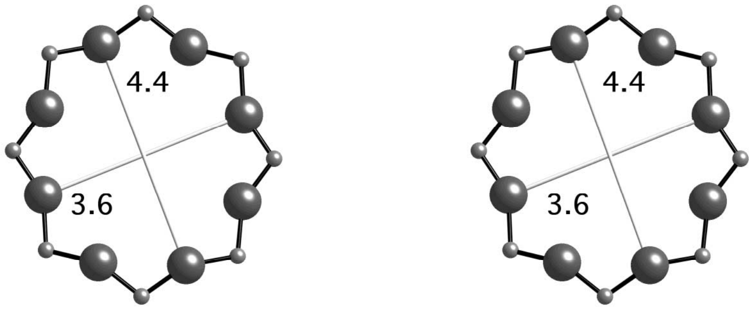
Isotypic framework structures:

*Deca-dodecasil 3R[1]
Sigma-1[2]
ZSM-58[3,4]

Crystal chemical data: |$(C_{10}H_{17}N)_6$ $(N_2)_9$| **[**Si_{120} O_{240}**]-DDR**
$C_{10}H_{17}N$ = 1-aminoadamantane
trigonal, $R\bar{3}m$, a = 13.860Å, c = 40.891Å (1)

Framework density: 17.6 T/1000Å^3

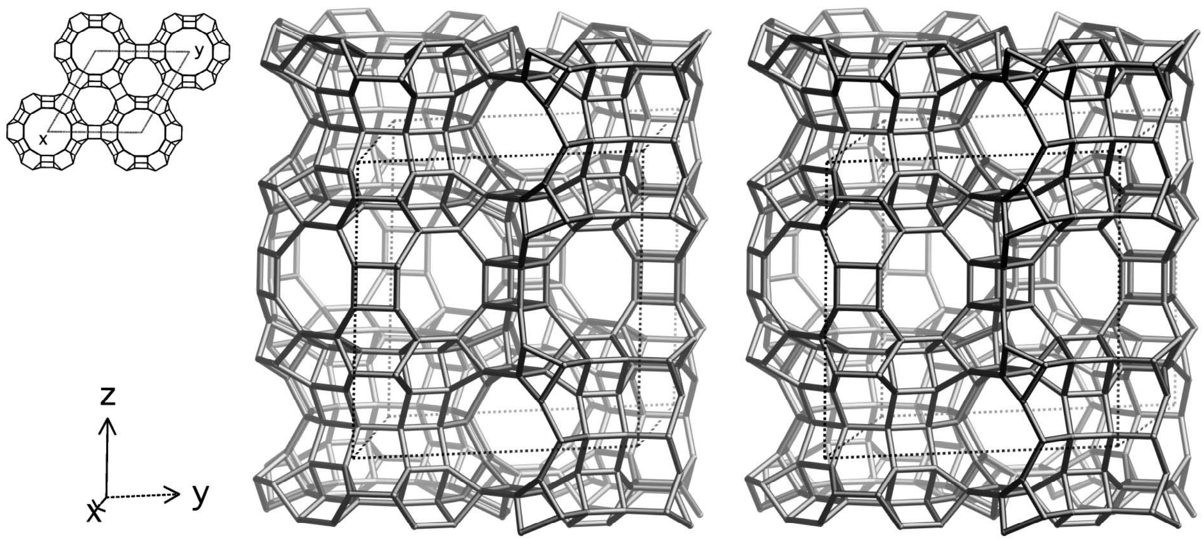
Channels: ⊥ [001] **8** 3.6 x 4.4**



8-ring viewed normal to [001]

References:

(1) Gies, H. *Z. Kristallogr.*, **175**, 93-104 (1986)
(2) Stewart, A., Johnson, D.W. and Shannon, M.D. *Stud. Surf. Sci. Catal.*, **37**, 57-64 (1988)
(3) Valyocsik, E.W. *U.S. Patent 4,698,217* (1987)
(4) Ernst, S., Chen, C.Y., Lindner, D. and Weitkamp, J. In *Zeolites for the Nineties*, *Recent Progress Reports - Abstracts*, (eds. J.C. Jansen, L. Moscou and M.F.M. Post), pp. 55-56 (1989), 8th IZC, Amsterdam



framework viewed normal to [001] (top left: projection down [001])

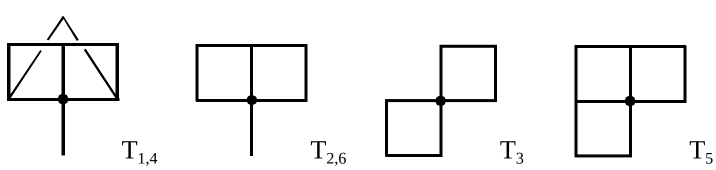
Idealized cell constants: hexagonal, P6/mmm, a = 22.0Å, c = 21.2Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	16	26	41	60	82	107	135	167	$4{\cdot}6_3{\cdot}4{\cdot}6_3{\cdot}4{\cdot}12$
T_2 (24, 1)	4	10	18	27	42	62	84	109	135	167	$4{\cdot}6_2{\cdot}4{\cdot}8{\cdot}6{\cdot}6_2$
T_3 (24, 1)	4	10	18	28	45	65	84	106	134	173	$4{\cdot}4{\cdot}6{\cdot}6_3{\cdot}6_3{\cdot}10$
T_4 (24, 1)	4	9	17	29	45	63	82	106	136	168	$4{\cdot}6{\cdot}4{\cdot}6_2{\cdot}4{\cdot}8$
T_5 (24, 1)	4	9	17	29	44	62	85	112	139	169	$4{\cdot}4{\cdot}4{\cdot}6{\cdot}6{\cdot}6_2$
T_6 (12, m)	4	10	18	28	45	66	89	115	141	171	$4{\cdot}6_2{\cdot}4{\cdot}6_2{\cdot}10{\cdot}12$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *DAF-1[1]

References:

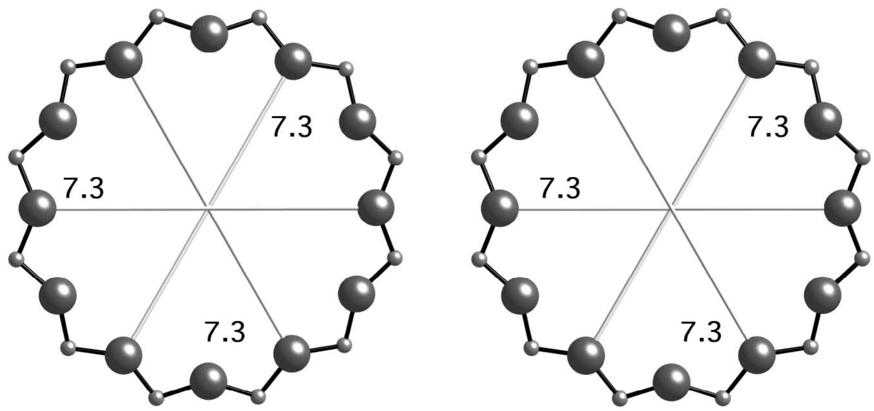
(1) Wright, P.A., Jones, R.H., Natarajan, S., Bell, R.G., Chen, J.S., Hursthouse, M.B. and Thomas, J.M. *Chem. Commun.*, 633-635 (1993)

Crystal chemical data: $|(C_{16}H_{38}N_2^{2+})_7\ (H_2O)_{40}|$ **[**$Mg_{14}Al_{52}P_{66}\ O_{264}$**]-DFO**
$C_{16}H_{38}N_2^{2+}$ = decamethonium
hexagonal, P6/mmm, a = 22.351Å, c = 21.693Å [1]

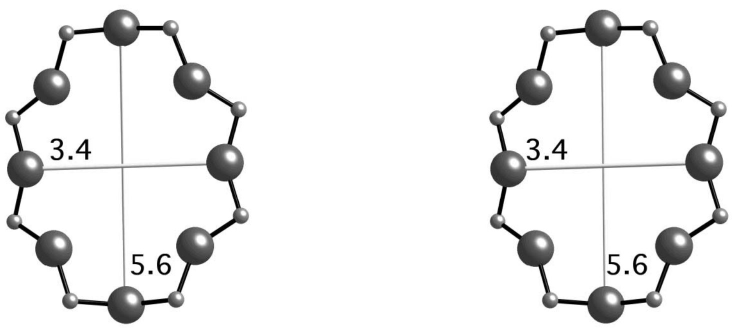
Framework density: 14.1 T/1000Å^3

Channels: {[001] **12** 7.3 x 7.3 ↔ ⊥[001] **8** 3.4 x 5.6}*** ↔ {[001] **12** 6.2 x 6.2 ↔ ⊥ [001] **10** 5.4 x 6.4}***

Stability: Transforms to $AlPO_4$-5 and $AlPO_4$-tridymite on heating to 500ºC [1]

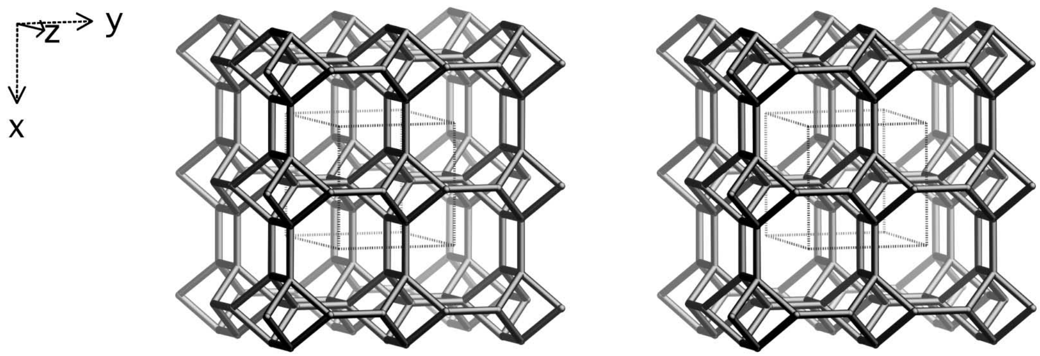


12-ring viewed along [001]



8-ring viewed normal to [001]

See Appendix A for 2nd 12-ring viewed along [001] and 10-ring viewed normal to [001]



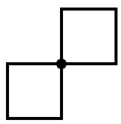
framework viewed along 001]

Idealized cell constants: tetragonal, $P4_2/mmc$, a = 7.1Å, c = 9.0Å

Coordination sequences and vertex symbols: T_1 (8, m) 4 10 21 36 55 79 106 138 175 215 $4 \cdot 4 \cdot 6_2 \cdot 8_3 \cdot 6_2 \cdot 8_3$

Secondary building units: 4

Loop configuration of T-Atoms:



T_1

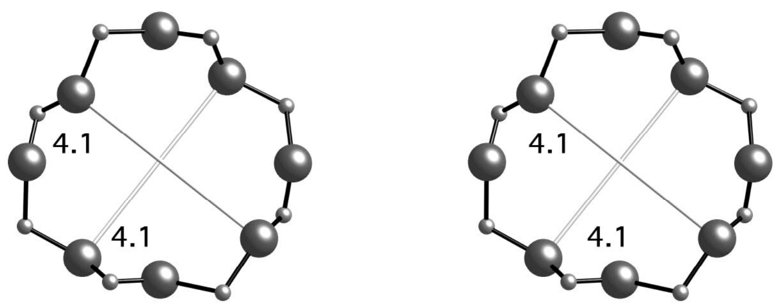
Isotypic framework structures:
*DAF-2[1]
ACP-3[2]
UCSB-3GaGe[3]
UCSB-3ZnAs[2]
UiO-20[4]

References:
(1) Chen, J., Jones, R.H., Natarajan, S., Hursthouse, M.B. and Thomas, J.M. *Angew. Chem., Int. Ed.*, **33**, 639-640 (1994)
(2) Bu, X., Feng, P., Gier, T.E. and Stucky, G.D. *J. Solid State Chem.*, **136**, 210-215 (1998)
(3) Bu, X., Feng, P., Gier, T.E., Zhao, D. and Stucky, G.D. *J. Am. Chem. Soc.*, **120**, 13389-13397 (1998)
(4) Kongshaug, K.O., Fjellvag, H. and Lillerud, K.P. *Chem. Mater.*, **12**, 1095-1099 (2000)

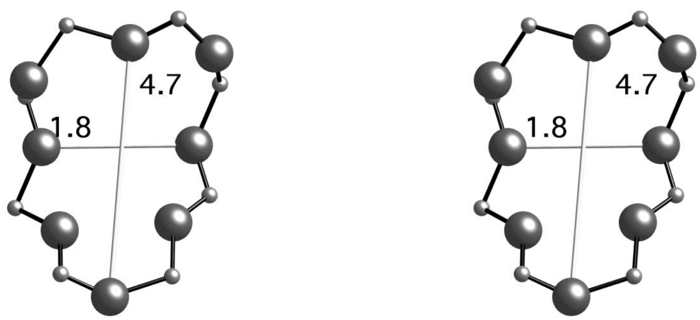
Crystal chemical data: **|**$(C_2H_{10}N_2^{2+})_2$**|** **[**$Co_4P_4\ O_{16}$**]-DFT**
$C_2H_8N_2$ = ethylenediamine
monoclinic, I112/b
a = 14.719Å, b = 14.734Å, c = 17.891Å, γ = 90.02° (1)
(Relationship to unit cell of Framework Type: a' = 2a, b' = 2b, c' = 2c)

Framework density: 16.5 T/1000Å^3

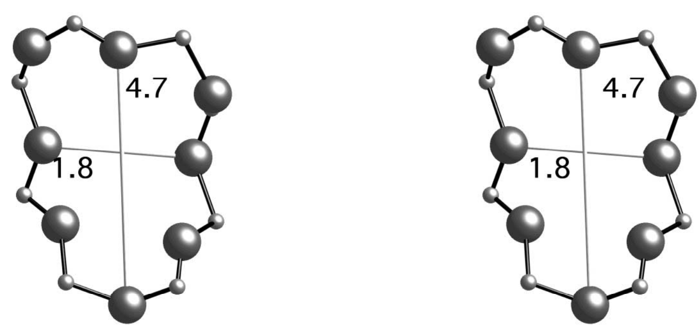
Channels: [001] **8** 4.1 x 4.1* ↔ [100] **8** 1.8 x 4.7* ↔ [010] **8** 1.8 x 4.7*



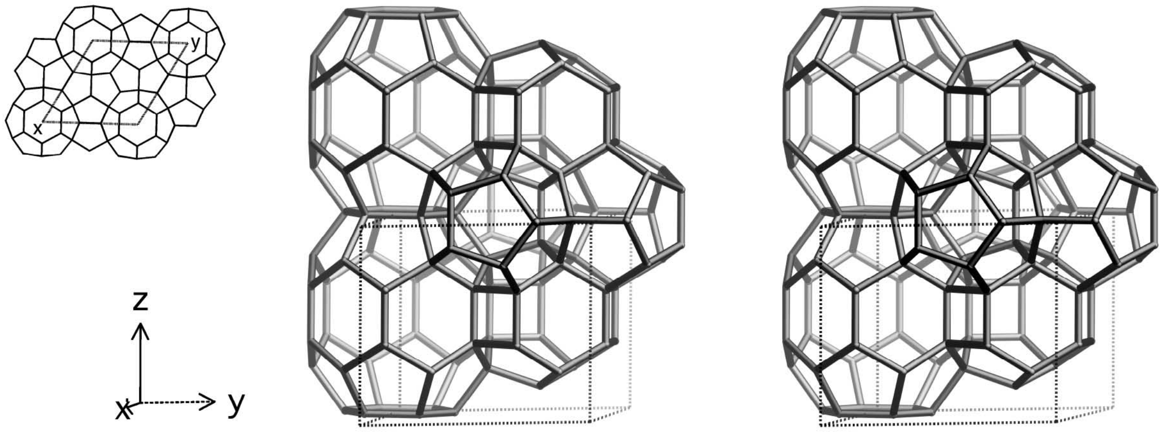
8-ring viewed along [001]



8-ring viewed along [100]



8-ring viewed along [010]



framework viewed normal to [001] (top left: projection down [001])

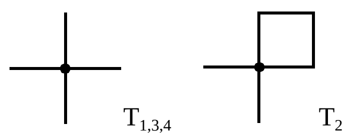
Idealized cell constants: hexagonal, P6/mmm, a = 14.2Å, c = 11.5Å

Coordination sequences and vertex symbols:

T_1 (12, m)	4	12	23	41	64	92	128	167	207	259	5·5·5·5·5·6
T_2 (12, m)	4	11	24	41	63	91	128	171	214	259	4·5·5·6·5·6
T_3 (6, mm2)	4	12	25	42	68	90	122	167	210	268	5·5·5·5·5·6
T_4 (4, 3m)	4	12	24	36	61	101	133	156	204	256	5·5·5·5·5·5

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *Dodecasil 1H[1]

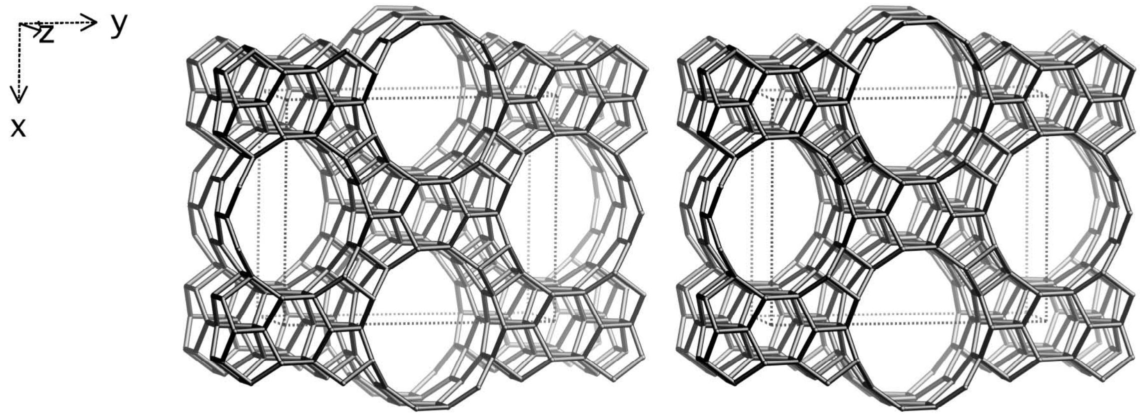
References:

(1) Gerke, H. and Gies, H. *Z. Kristallogr.*, **166**, 11-22 (1984)

Crystal chemical data: **|**$C_5H_{11}N\ (N_2)_5$**|** **[**$Si_{34}\ O_{68}$**]-DOH**
$C_5H_{11}N$ = piperidine
hexagonal, P6/mmm, a = 13.783Å, c = 11.190Å [(1)]

Framework density: 18.5 T/1000Å^3

Channels: apertures formed by 6-rings only



framework viewed along [001]

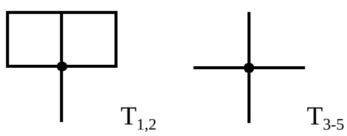
Idealized cell constants: orthorhombic, Cmcm, a = 18.9Å, b = 23.4Å, c = 8.5Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	10	20	34	54	77	107	140	175	218	$4\cdot6\cdot4\cdot6_2\cdot5\cdot6$
T_2 (16, 1)	4	10	20	35	54	77	106	138	177	221	$4\cdot6\cdot4\cdot6_2\cdot5\cdot6$
T_3 (16, 1)	4	12	24	38	55	76	105	143	184	223	$5\cdot6_2\cdot6\cdot6_2\cdot6\cdot6_2$
T_4 (8, m)	4	12	22	33	53	80	109	143	179	217	$5\cdot6\cdot5\cdot6\cdot6\cdot6_2$
T_5 (8, m)	4	12	23	37	52	74	107	143	183	223	$5\cdot6_2\cdot5\cdot6_2\cdot6_2\cdot6_2$

Secondary building units: 5-3

Loop configuration of T-Atoms:



Isotypic framework structures: *UTD-1F[(1)]
UTD-1[(2)]

References:

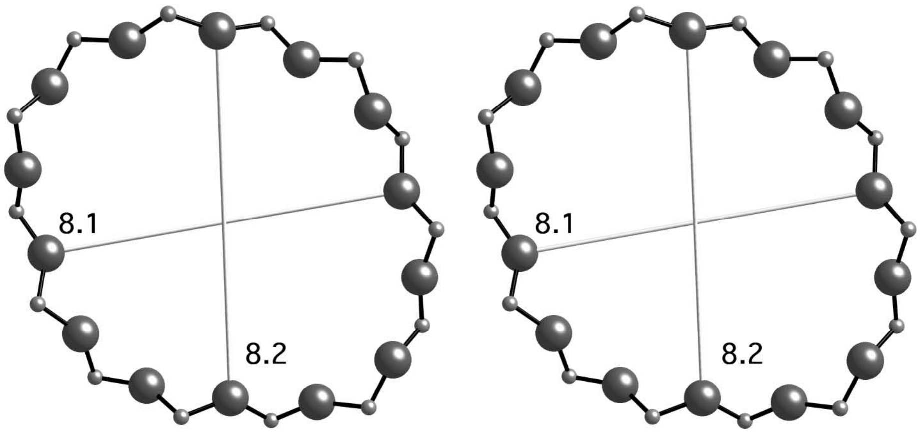
(1) Wessels, T., Baerlocher, C., McCusker, L.B. and Creyghton, E.J. *J. Am. Chem. Soc.*, **121**, 6242-6247 (1999)

(2) Lobo, R.F., Tsapatsis, M., Freyhardt, C.C., Khodabandeh, S., Wagner, P., Chen, C.Y., Balkus, K.J., Zones, S.I. and Davis, M.E. *J. Am. Chem. Soc.*, **119**, 8474-8484 (1997)

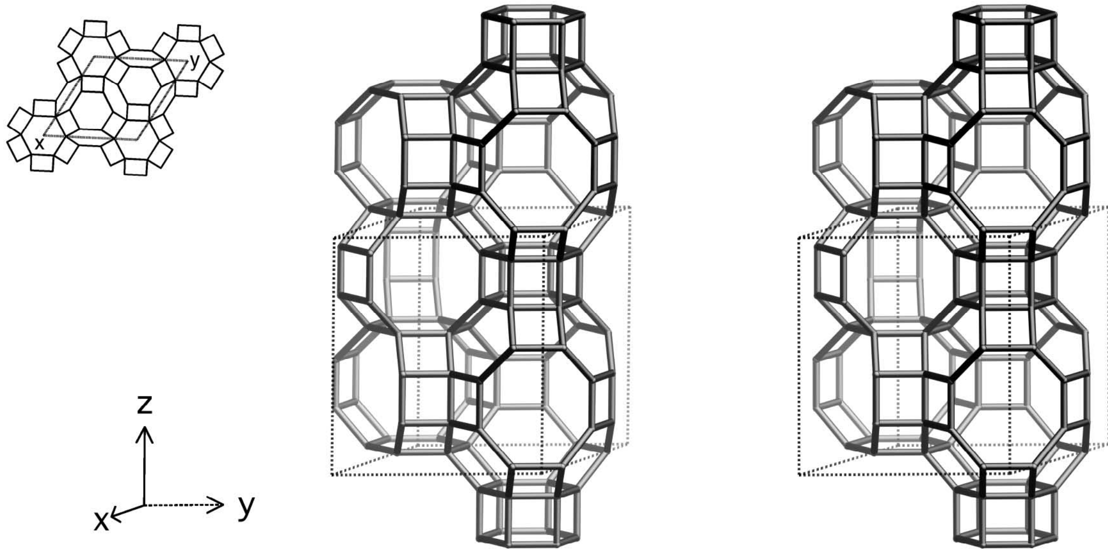
Crystal chemical data: |$((Cp^*)_2Co)^+_2$ $F^-_{1.5}(OH)^-_{0.5}$| [Si_{64} O_{128}]-**DON**
Cp* = pentamethylcyclopentadiene
monoclinic, P1c1, a = 14.970Å, b = 8.476Å, c = 30.028Å, β = 102.65° (1)

Framework density: 17.2 T/1000$Å^3$

Channels: [010] **14** 8.1 x 8.2*



14-ring viewed along [010]



framework viewed normal to [001] (top left: projection down [001])

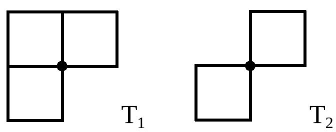
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 13.2Å, c = 15.0Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	30	49	71	92	115	147	190	4·4·4·6·6·8
T_2 (12, 2)	4	10	20	32	46	66	94	128	162	192	4·4·6·6·8·8

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



Framework description: ABBACC sequence of 6-rings

Isotypic framework structures: *TMA-E (Aiello and Barrer)[1,2]
Bellbergite[3]

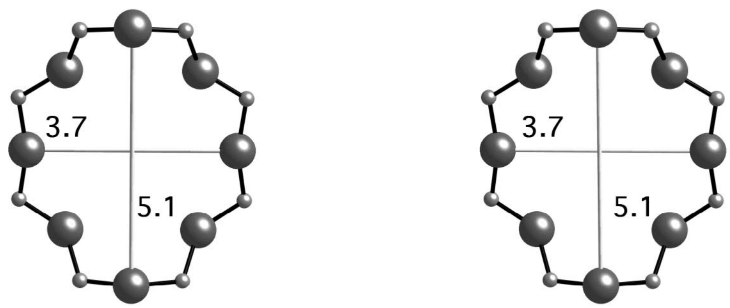
References:

(1) Aiello, R. and Barrer, R.M. *J. Chem. Soc. (A)*, 1470-1475 (1970)
(2) Meier, W.M. and Groner, M. *J. Solid State Chem.*, **37**, 204-218 (1981)
(3) Rüdinger, B., Tillmanns, E. and Hentschel, G. *Miner. Petrol.*, **48**, 147-152 (1993)

Crystal chemical data: **|**$(C_4H_{12}N^+)_2Na^+_7\ (H_2O)_{26}$**|** **[**$Al_9Si_{27}\ O_{72}$**]-EAB**
$C_4H_{12}N^+$ = tetramethylammonium
hexagonal, $P6_3/mmc$, a = 13.28Å, c = 15.21Å [(2)]

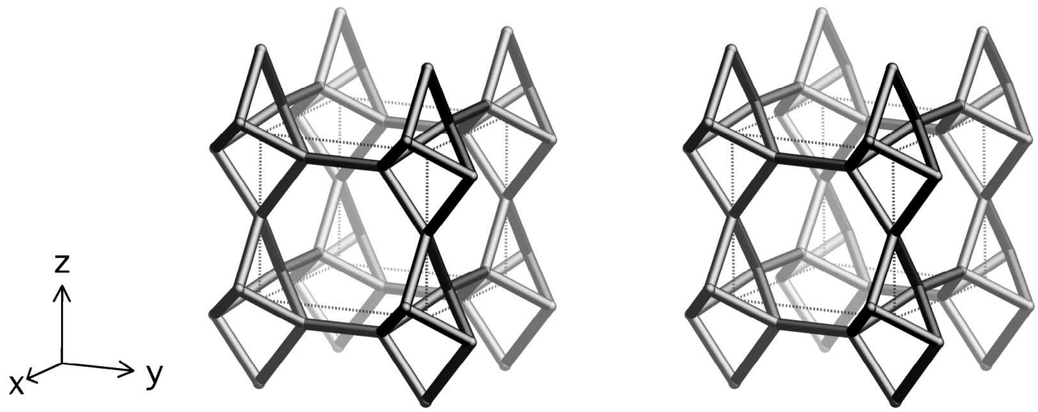
Framework density: 15.5 T/1000Å^3

Channels: ⊥ [001] **8** 3.7 x 5.1**



8-ring viewed normal to [001]

EDI Framework Type $P\bar{4}m2$



framework viewed normal to [001]

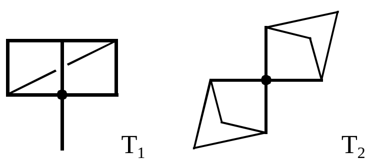
Idealized cell constants: tetragonal, $P\bar{4}m2$, a = 6.9Å, c = 6.4Å

Coordination sequences and vertex symbols:

T_1 (4, m)	4	9	19	35	52	72	100	131	163	201	$4\cdot8_3\cdot4\cdot8_3\cdot4_2\cdot8_4$
T_2 (1, $\bar{4}$m2)	4	8	18	32	52	74	100	128	162	204	$4_2\cdot4_2\cdot8_4\cdot8_4\cdot8_4\cdot8_4$

Secondary building units: 4=1

Loop configuration of T-Atoms:



Isotypic framework structures:

*Edingtonite[1-3]
[Co-Al-P-O**]-EDI**[4]
[Co-Ga-P-O**]-EDI**[4]
K-F[5,6]
Linde F[7]
Synthetic edingtonite[8]
Tetragonal edingtonite[9]
Zeolite N[10] (not to be confused with Linde N)

References:

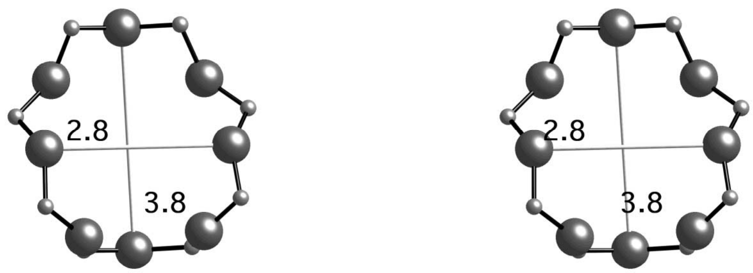
(1) Taylor, W.H. and Jackson, R. *Z. Kristallogr.*, **86**, 53-64 (1933)
(2) Galli, E. *Acta Crystallogr.*, **B32**, 1623-1627 (1976)
(3) Kvick, Å. and Smith J.V. *J. Chem. Phys.*, **79**, 2356-2362 (1983)
(4) Bu, X., Gier, T.E., Feng, P. and Stucky, G.D. *Chem. Mater.*, **10**, 2546-2551 (1998)
(5) Barrer, R.M. and Baynham, J.W. *J. Chem. Soc.*, 2882-2891 (1956)
(6) Baerlocher, Ch. and Barrer, R.M. *Z. Kristallogr.*, **140**, 10-26 (1974)
(7) Sherman, J.D. *ACS Sym. Ser.*, **40**, 30-42 (1977)
(8) Ghobarkar, H. and Schaef, O. *Cryst. Res. Technol.*, **32**, 653-657 (1997)
(9) Mazzi, F., Galli, E. and Gottardi, G. *N. Jb. Miner. Mh.*, 373-382 (1984)
(10) Christensen, A.N. and Fjellvåg, H. *Acta Chemica Scand.*, **51**, 969-973 (1997)

Edingtonite Type Material EDI

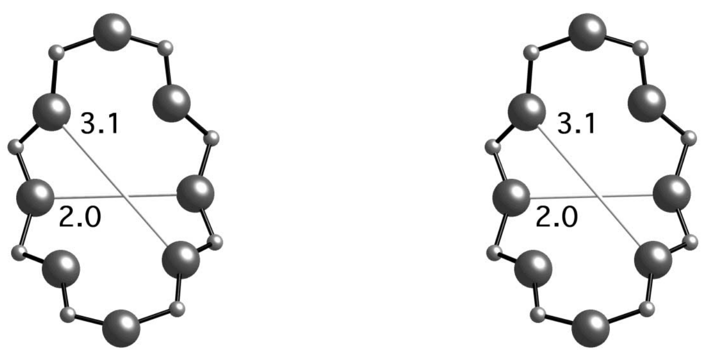
Crystal chemical data: |Ba^{2+}_2 $(H_2O)_8$| **[**Al_4Si_6 O_{20}**]-EDI**
orthorhombic, $P2_12_12$, a = 9.550Å, b = 9.665Å, c = 6.523Å [(2)]
(Relationship to unit cell of Framework Type:
a' = a·sqrt(2), b' = b·sqrt(2), c' = c
or, as vectors, **a'** = **a** + **b**, **b'** = **b** - **a**, **c'** = **c**)

Framework density: 16.6 T/1000$Å^3$

Channels: <110> **8** 2.8 x 3.8** ↔ [001] **8** 2.0 x 3.1* (variable due to considerable flexibility of the framework)

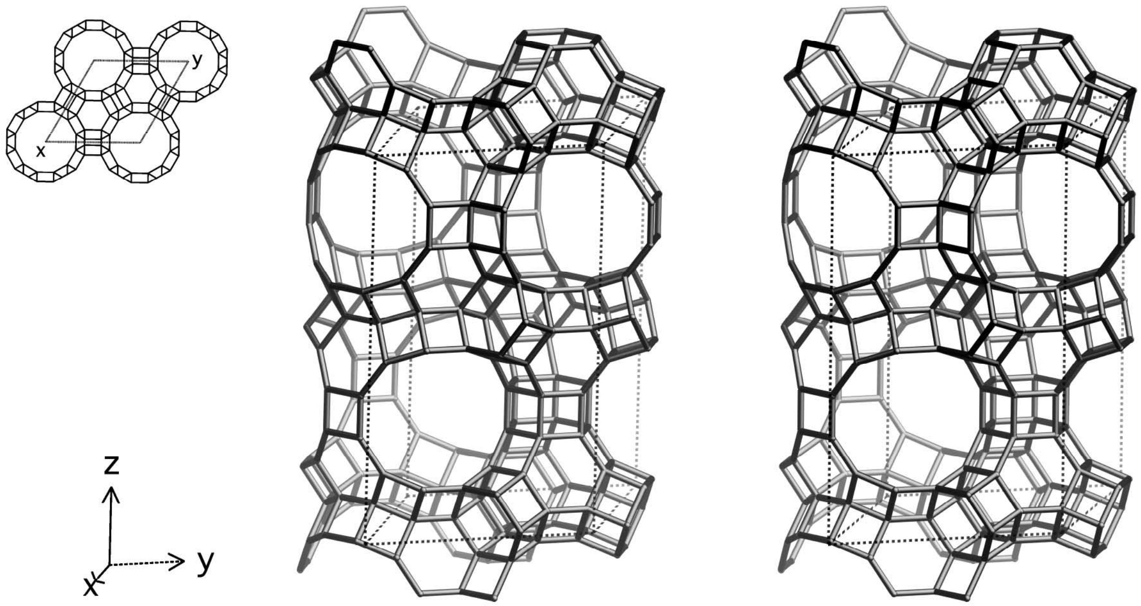


8-ring viewed along <110>



8-ring viewed along [001] (variable)

EMT Framework Type $P6_3/mmc$



framework viewed normal to [001] (top left: projection down [001])

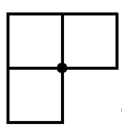
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 17.2Å, c = 28.1Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	16	25	37	53	73	96	121	148		4·4·4·6·6·12
T_2 (24, 1)	4	9	16	25	37	53	73	96	121	148		4·4·4·6·6·12
T_3 (24, 1)	4	9	16	25	37	53	73	97	124	152		4·4·4·6·6·12
T_4 (24, 1)	4	9	16	25	37	53	73	96	120	145		4·4·4·6·6·12

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



T_{1-4}

Framework description: structural derivative of hexagonal diamond and tridymite, respetively

Isotypic framework structures:

*EMC-2[1,2]
CSZ-1 (**EMT-FAU** structural intermediate)[3]
ECR-30 (**EMT-FAU** structural intermediate)[4]
ZSM-20 (**EMT-FAU** structural intermediate)[5]
ZSM-3 (**EMT-FAU** structural intermediate)[6]

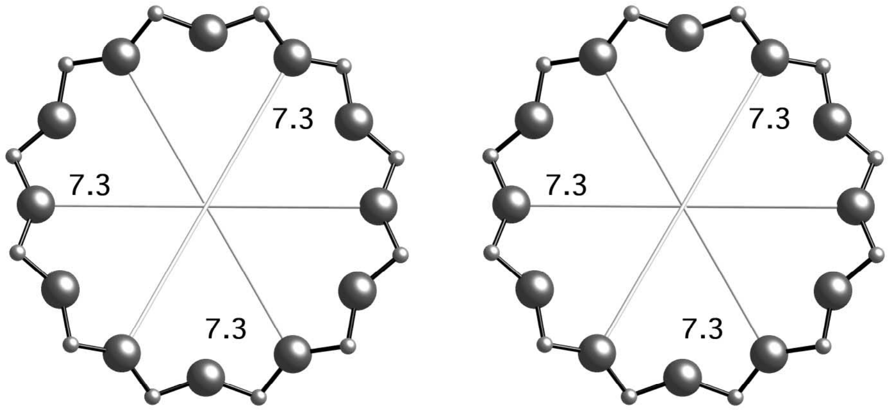
Alternate designation:

Breck structure six (improper)
BSS (improper)
hexagonal faujasite

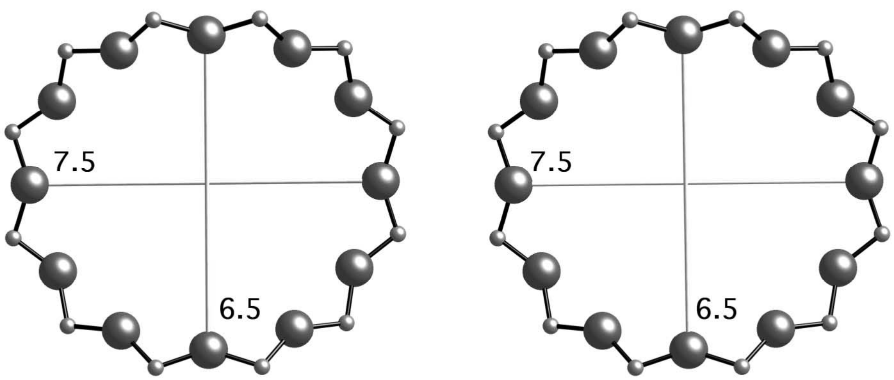
Crystal chemical data: $|Na^{+}_{21}\ (C_{12}H_{24}O_6)_4|$ **[**$Al_{21}Si_{75}\ O_{192}$**]-EMT**
$C_{12}H_{24}O_6$ = 18-crown-6
hexagonal, $P6_3/mmc$, a = 17.374Å, c = 28.365Å [(2)]

Framework density: 12.9 T/1000Å^3

Channels: [001] **12** 7.3 x 7.3* ↔ ⊥ [001] **12** 6.5 x 7.5**



12-ring viewed along [001]

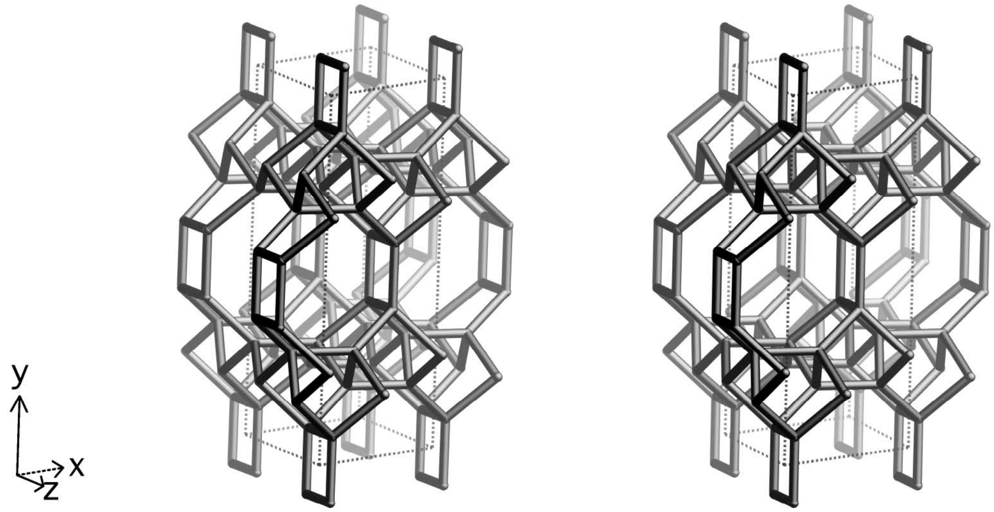


12-ring viewed normal to [001]

References:

(1) Delprato, F., Delmotte, L., Guth, J.L. and Huve, L. *Zeolites*, **10**, 546-552 (1990)
(2) Baerlocher, Ch., McCusker, L.B. and Chiappetta, R. *Microporous Materials*, **2**, 269-280 (1994)
(3) Barrett, M.G. and Vaughan, D.E.W. *UK Patent GB 2,076,793* (1981)
(4) Vaughan, D.E.W. *E. Patent 0,351,461* (1989)
(5) Newsam, J.M., Treacy, M.M.J., Vaughan, D.E.W., Strohmaier, K.G. and Mortier, W.J. *Chem. Commun.*, 493-495 (1989)
(6) Kokotailo, G.T. and Ciric, J. *Adv. Chem. Ser.* , **101**, 109-121 (1971)

EPI Framework Type C2/m



framework viewed along [001]

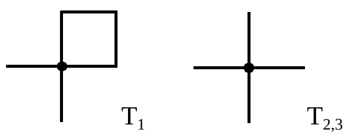
Idealized cell constants: monoclinic, C2/m, a = 9.1Å, b = 17.5Å, c = 10.4Å, β = 124.9°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	24	42	63	93	127	160	206	262	$4·5_2·5·8·5·8$
T_2 (8, 1)	4	12	22	37	64	94	119	161	204	252	$5·5·5·5_2·8·10_2$
T_3 (8, 1)	4	12	20	39	66	90	118	164	214	245	$5·5·5·5_2·5·8$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures: *Epistilbite[1-4]
Synthetic epistilbite[5]

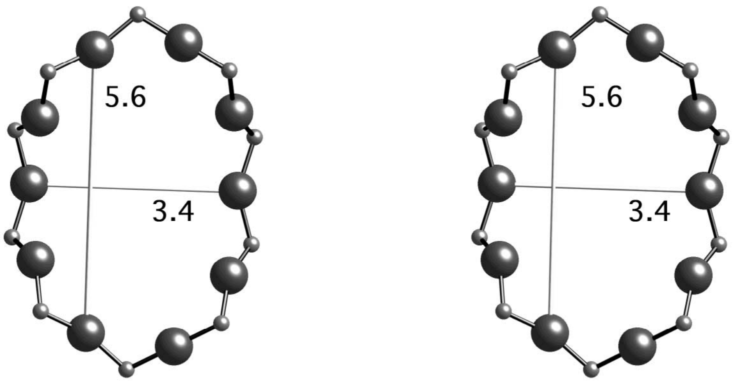
References:

(1) Kerr, I.S. *Nature*, **202**, 589 (1964)
(2) Perrotta, A.J. *Mineral. Mag.*, **36**, 480-490 (1967)
(3) Alberti, A., Galli, E. and Vezzalini, G. *Z. Kristallogr.*, **173**, 257-265 (1985)
(4) Yang, P. and Armbruster, T. *Eur. J. Mineral.*, **8**, 263-271 (1996)
(5) Ghobarkar, H. *Cryst. Res. Technol.*, 151-1573 (1984)

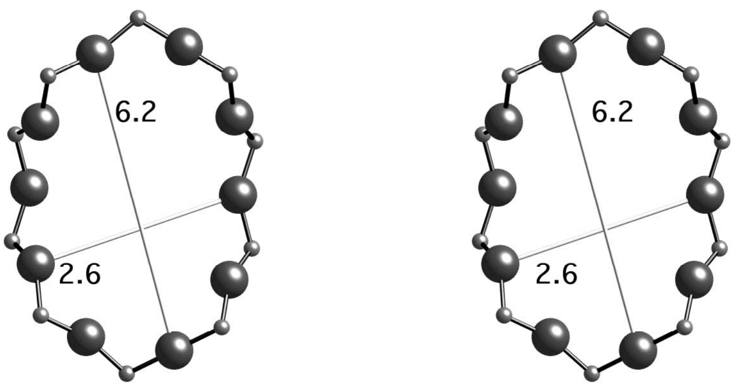
Crystal chemical data: |Ca^{2+}_3 $(H_2O)_{16}$| **[**Al_6Si_{18} O_{48}**]-EPI**
monoclinic, C2/m, a = 9.08Å, b = 17.74Å, c = 10.25Å, β = 124.54° (2)

Framework density: 17.6 T/1000Å^3

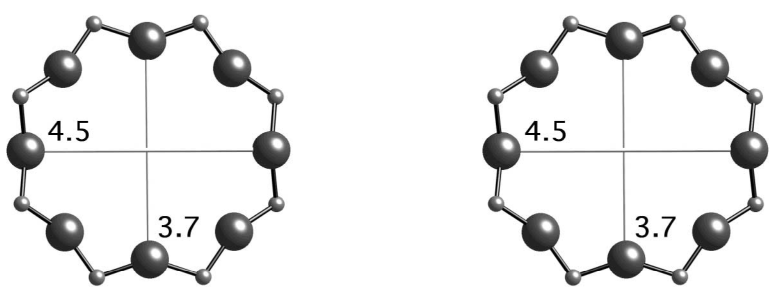
Channels: [100] **10** 3.4 x 5.6* $\leftrightarrow$ [001] **8** 3.7 x 4.5*



10-ring viewed along [100] associated

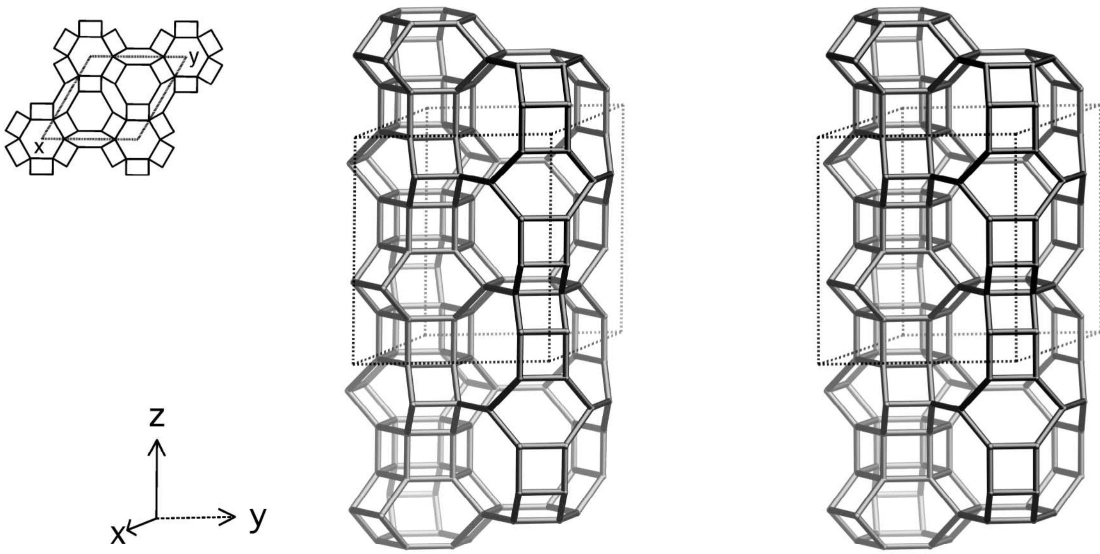


with second 10-ring along [100]



8-ring viewed along [001]

ERI Framework Type $P6_3/mmc$



framework viewed normal to [001] (top left: projection down [001])

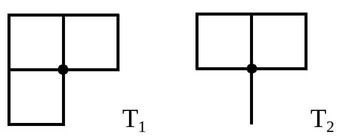
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 13.1Å, c = 15.2Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	30	50	75	98	118	144	185	4·4·4·6·6·8
T_2 (12, m)	4	10	20	32	46	64	90	126	164	196	4·8·4·8·6·6

Secondary building units: 6 or 4

Loop configuration of T-Atoms:



Framework description: AABAAC sequence of 6-rings

Isotypic framework structures:
*Erionite[1-3]
AlPO-17 plus numerous compositional variants[4-6]
LZ-220[7]
Linde T (**ERI-OFF** structural intermediate)[8]

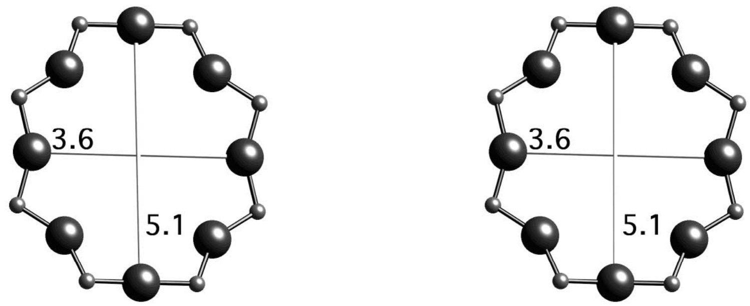
References:

(1) Staples, L.W. and Gard, J.A. *Mineral. Mag.*, **32**, 261-281 (1959)
(2) Kawahara, A. and Curien, H. *Bull. Soc. fr. Minéral. Cristallogr.*, **92**, 250-256 (1969)
(3) Gard, J.A. and Tait, J.M. In *Proc. 3rd Int. Conf. Molecular Sieves*, (ed. J.B. Uytterhoeven), pp. 94-99 (1973), Leuven University Press, Leuven
(4) Pluth, J.J., Smith, J.V. and Bennett, J.M. *Acta Crystallogr.*, **C42**, 283-286 (1986)
(5) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)

Crystal chemical data: |$(Ca^{2+},Na^{+}{}_2)_{3.5}$ $K^{+}{}_2$ $(H_2O)_{27}$| [Al_9Si_{27} O_{72}]-**ERI**
hexagonal, $P6_3/mmc$, a = 13.27Å, c = 15.05Å [(3)]

Framework density: 15.7 T/1000Å^3

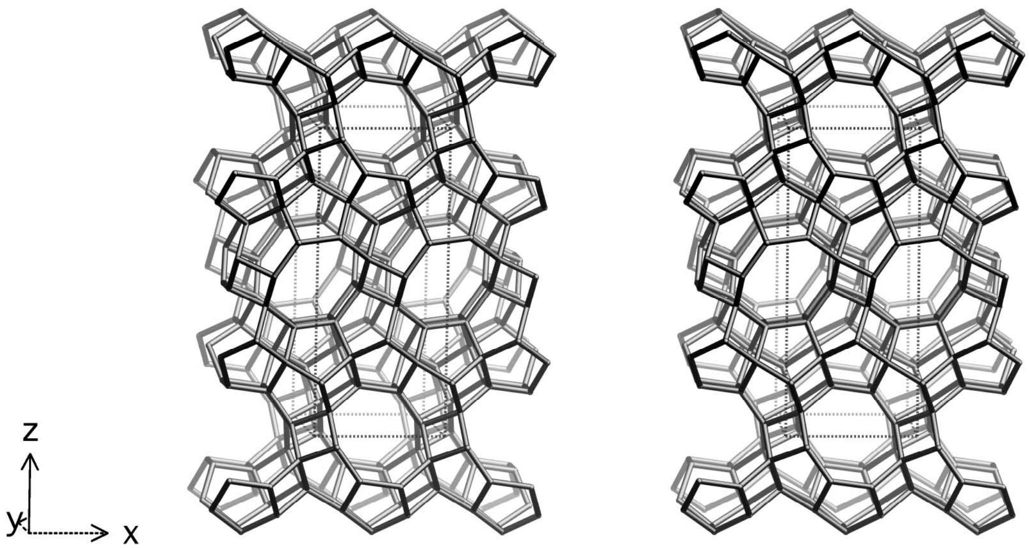
Channels: ⊥ [001] **8** 3.6 x 5.1***



8-ring viewed normal to [001]

References (cont.):

(6) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo
(7) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(8) Breck, D.W. *Zeolite Molecular Sieves*, p. 173 (1974), Wiley, New York



framework viewed along [010]

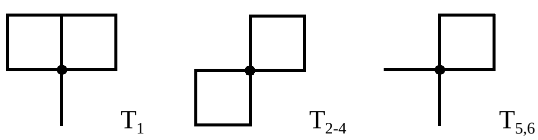
Idealized cell constants: orthorhombic, Pnma, a = 9.7Å, b = 12.2Å, c = 22.8Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	20	35	56	82	111	143	180	228	4·5·4·5·6·8
T_2 (8, 1)	4	10	20	36	58	82	109	144	186	230	4·4·5·6·6·8
T_3 (8, 1)	4	10	21	36	57	82	111	145	183	231	4·4·5·8·6·6
T_4 (8, 1)	4	10	21	36	56	82	113	145	180	224	4·4·5·6·6·8
T_5 (8, 1)	4	11	22	36	56	78	110	148	184	225	4·6·5·6·5·6
T_6 (8, 1)	4	11	20	37	54	82	112	142	182	226	4·5·5·5·6·6

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures: *ERS-7[1,2]

References:

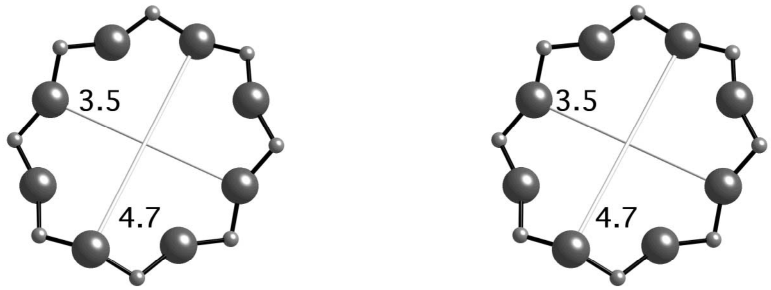
(1) Campbell, B.J., Bellussi, G., Carluccio, L., Perego, G., Cheetham, A.K., Cox, D.E. and Millini, R. *Chem. Commun.*, 1725-1726 (1998)

(2) Millini, R., Perego, G., Carluccio, L., Bellussi, G., Cox, D.E., Campbell, B.J. and Cheetham, A.K. In *Proc. 12th Int. Zeolite Conf.*, (eds. M.M.J. Treacy, B.K. Marcus, M.E. Bisher and J.B. Higgins), pp. 541-548 (1999), MRS, Warrendale, PA

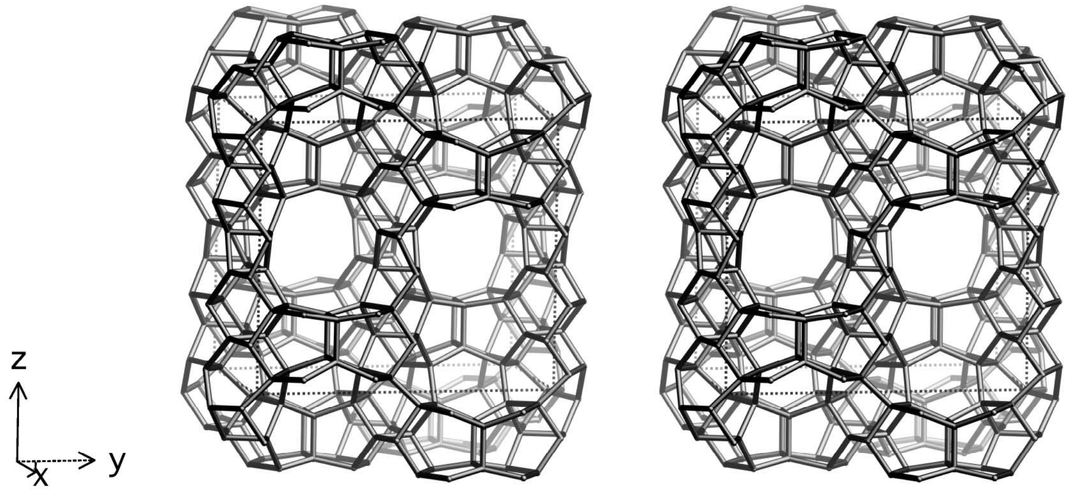
Crystal chemical data: **|**$H^+_{5.06}Na^+_{0.07}$**|** **[**$Al_{5.13}Si_{42.87}O_{96}$**]-ESV**
orthorhombic, Pnma, a = 9.780Å, b = 12.412Å, c = 22.861Å [(2)]

Framework density: 17.3 T/1000Å^3

Channels: [010] **8** 3.5 x 4.7*



8-ring viewed along [010]



framework viewed along [100]

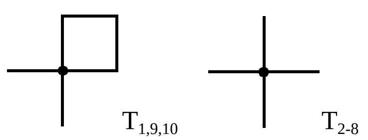
Idealized cell constants: orthorhombic, Cmma, a = 13.9Å, b = 22.9Å, c = 20.6Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	21	36	59	92	129	167	197	246	$4\cdot6\cdot5\cdot5\cdot5_2\cdot10$
T_2 (16, 1)	4	12	25	41	64	88	122	160	202	256	$5\cdot6\cdot5\cdot6\cdot5\cdot6$
T_3 (16, 1)	4	12	23	38	60	89	124	159	194	248	$5\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_4 (16, 1)	4	12	22	39	59	91	124	160	206	257	$5\cdot5\cdot5\cdot6_2\cdot5\cdot10$
T_5 (8, m)	4	12	20	31	61	88	120	159	197	248	$5\cdot5\cdot5\cdot5\cdot5\cdot6_2$
T_6 (8, m)	4	12	20	34	57	92	131	164	202	236	$5\cdot5_2\cdot5\cdot5_2\cdot12_2\cdot*$
T_7 (8, m)	4	12	24	39	60	91	126	161	195	243	$5\cdot6\cdot5\cdot6\cdot5\cdot6_2$
T_8 (8, m)	4	12	24	36	56	90	127	157	197	236	$5\cdot5\cdot5\cdot5\cdot12_4\cdot*$
T_9 (8, m)	4	11	23	45	67	88	115	162	218	261	$4\cdot6\cdot5\cdot5\cdot5\cdot5$
T_{10} (8, m)	4	11	24	39	68	92	118	156	213	268	$4\cdot10\cdot5\cdot5\cdot5\cdot5$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:
*EU-1[1,2]
TPZ-3[3]
ZSM-50[4]

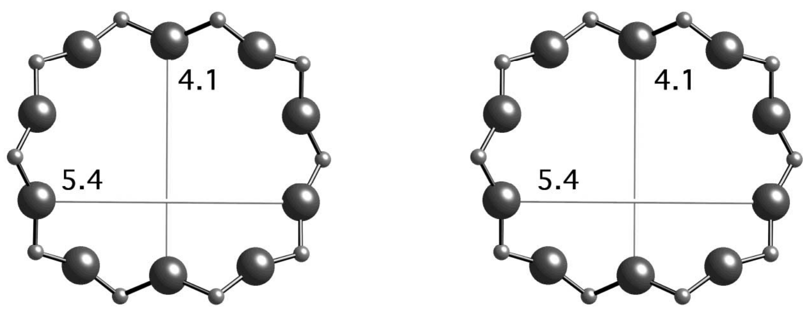
References:

(1) Casci, J.L., Lowe, B.M. and Whittam, T.V. *U.S. Patent 4,537,754*, (1985)
(2) Briscoe, N.A., Johnson, D.W., Shannon, M.D., Kokotailo, G.T. and McCusker, L.B. *Zeolites*, **8**, 74-76 (1988)
(3) Sumitani, K., Sakai, T., Yamasaki, Y. and Onodera, T. *E. Patent EP 51318* (1982)
(4) Rohrbaugh, W.J. *private communication*

Crystal chemical data: |Na^+_n $(H_2O)_{26}$| **[**Al_nSi_{112-n} O_{224}**]-EUO** , n < 19, typically n ~ 3.6
orthorhombic, Cmma, a = 13.695Å, b = 22.326Å, c = 20.178Å [(2)]

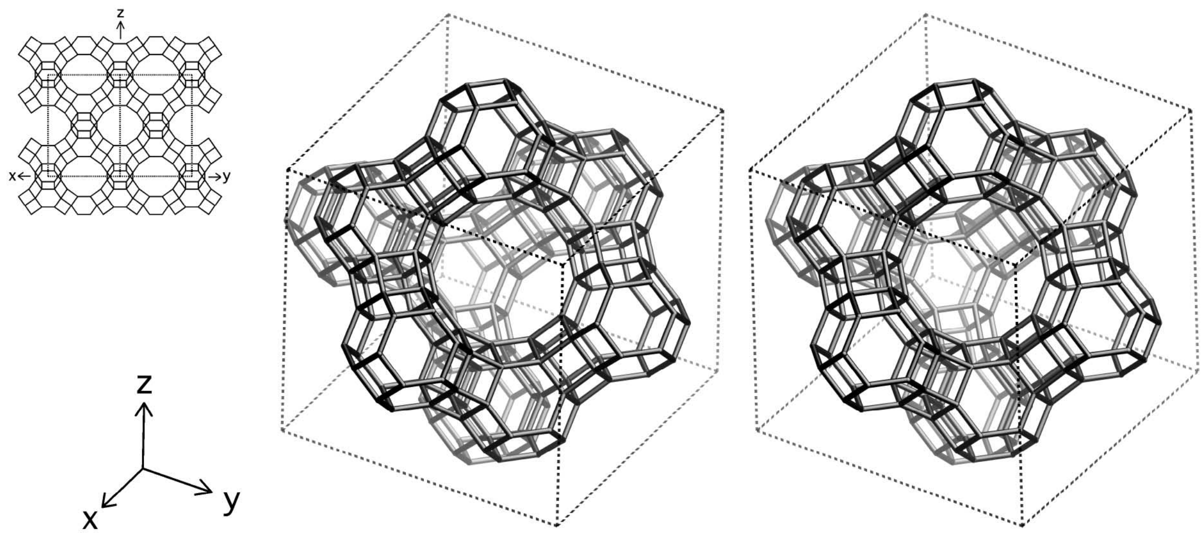
Framework density: 18.2 T/1000$Å^3$

Channels: [100] **10** 4.1 x 5.4* (with large side pockets)



10-ring viewed along [100]

FAU Framework Type $Fd\bar{3}m$



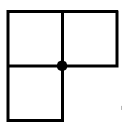
framework viewed along [111] (top left: projection down [110])

Idealized cell constants: cubic, $Fd\bar{3}m$ (origin choice 2), a = 24.3Å

Coordination sequences and vertex symbols: T_1 (192, 1) 4 9 16 25 37 53 73 96 120 145 4·4·4·6·6·12

Secondary building units: 6-6 or 6-2 or 6 or 4

Loop configuration of T-Atoms:



Framework description: structural derivative of diamond and cristobalite, respectively

Isotypic framework structures:

*Faujasite[1,2]
[Al-Ge-O**]-FAU**[3]
[Co-Al-P-O**]-FAU**[4]
[Ga-Ge-O**]-FAU**[3]
Beryllophosphate X[5]
CSZ-1 (**EMT-FAU** structural intermediate)[6]
ECR-30 (**EMT-FAU** structural intermediate)[7]
LZ-210[8]
Linde X[9,10]
Linde Y[11,12]
SAPO-37[13]
Siliceous Na-Y[14]
ZSM-20 (**EMT-FAU** structural intermediate)[15]
ZSM-3 (**EMT-FAU** structural intermediate)[16]
Zincophosphate X[5]

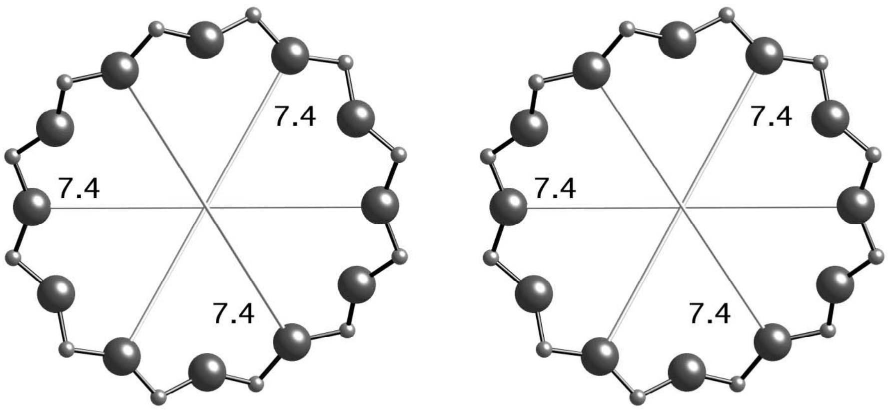
References:

(1) Bergerhoff, G., Baur, W.H. and Nowacki, W. *N. Jb. Miner. Mh.*, 193-200 (1958)
(2) Baur, W.H. *Am. Mineral.*, **49**, 697-704 (1964)

Crystal chemical data: **|**$(Ca^{2+},Mg^{2+}Na^{+}{}_2)_{29}$ $(H_2O)_{240}$**|** **[**$Al_{58}Si_{134}$ O_{384}**]-FAU**
cubic, $Fd\bar{3}m$, a = 24.74Å [(2)]

Framework density: 12.7 T/1000Å^3

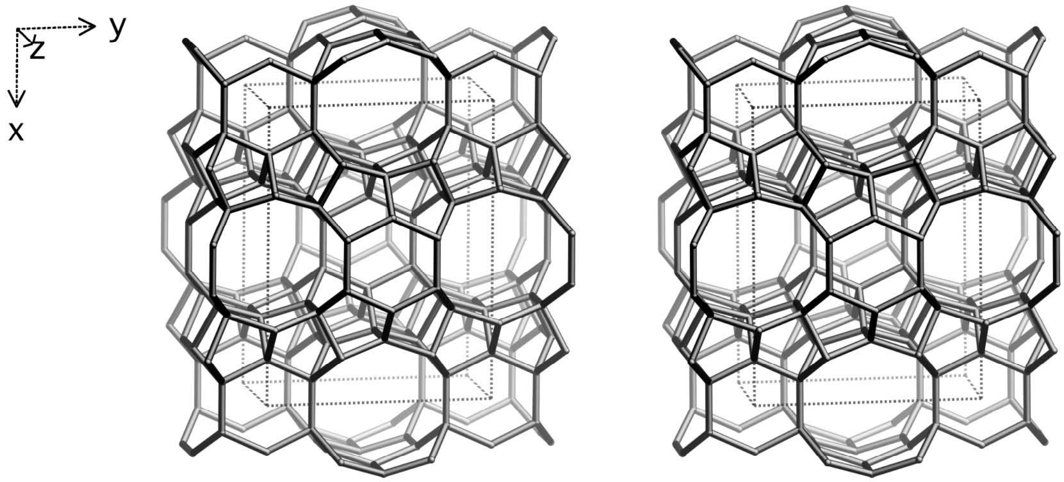
Channels: <111> **12** 7.4 x 7.4***



12-ring viewed along <111>

References (cont.):

(3) Barrer, R.M., Baynham, J.W., Bultitude, F.W. and Meier, W.M. *J. Chem. Soc.*, 195-208 (1959)
(4) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(5) Gier, T.E. and Stucky, G.D. *Zeolites*, **12**, 770-775 (1992)
(6) Barrett, M.G. and Vaughan, D.E.W. *UK Patent GB 2,076,793* (1981)
(7) Vaughan, D.E.W. *E. Patent 0,351,461* (1989)
(8) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(9) Milton, R.M. *U.S. Patent 2,882,244* (1959)
(10) Olson, D.H. *J. Phys. Chem.*, **74**, 2758-2764 (1970)
(11) Breck, D.W. *U.S. Patent 3,130,007* (1964)
(12) Costenoble, M.L., Mortier, W.J. and Uytterhoeven, J.B. *J. Chem. Soc., Faraday Trans. I*, **72**, 1877-1883 (1976)
(13) Lok, B.M., Messina, C.A., Patton, R.L., Gajek, R.T., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **106**, 6092-6093 (1984)
(14) Hriljac, J.J., Eddy, M.M., Cheetham, A.K., Donohue, J.A. and Ray, G.J. *J. Solid State Chem.*, **106**, 66-72 (1993)
(15) Newsam, J.M., Treacy, M.M.J., Vaughan, D.E.W., Strohmaier, K.G. and Mortier, W.J. *Chem. Commun.*, 493-495 (1989)
(16) Kokotailo, G.T. and Ciric, J. *Adv. Chem. Ser.* , **101**, 109-121 (1971)



framework viewed along [001]

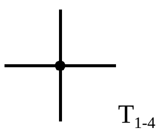
Idealized cell constants: orthorhombic, Immm, a = 19.0Å, b = 14.3Å, c = 7.5Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	12	21	39	66	95	126	169	221	265	$5\cdot5\cdot5\cdot5_2\cdot5\cdot8$
T_2 (8, m)	4	12	27	43	62	97	139	172	206	264	$5\cdot8\cdot5\cdot8\cdot5_2\cdot6$
T_3 (8, m)	4	12	20	35	67	104	121	157	223	276	$5\cdot5_2\cdot5\cdot5_2\cdot10_2\cdot12_2$
T_4 (4, 2mm)	4	12	23	40	66	96	131	164	214	272	$5\cdot5\cdot5\cdot5\cdot5_2\cdot6$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures:

*Ferrierite[1]
[Ga-Si-O**]-FER**[2]
[Si-O**]-FER**[3,4]
FU-9[5]
ISI-6[6]
Monoclinic ferrierite[7]
NU-23[8]
Sr-D[9]
ZSM-35[10]

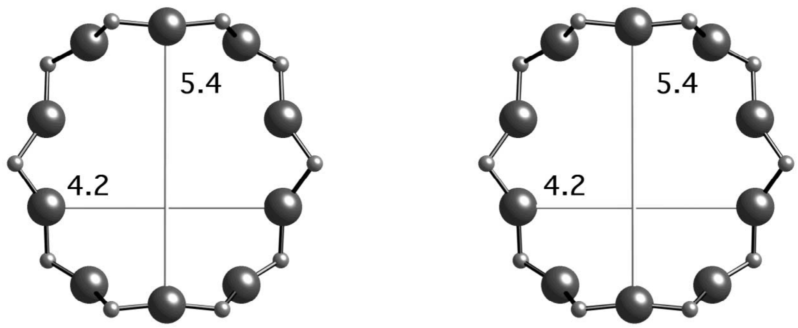
References:

(1) Vaughan, P.A. *Acta Crystallogr.*, **21**, 983-990 (1966)
(2) Jacob, N.E., Joshi, P.N., Shaikh, A.A. and Shiralkar, V.P. *Zeolites*, **13**, 430-434 (1993)
(3) Gies, H. and Gunawardane, R.P. *Zeolites*, **7**, 442-445 (1987)
(4) Morris, R.E., Weigel, S.J., Henson, N.J., Bull, L.M., Janicke, M.T., Chmelka, B.F. and Cheetham, A.K. *J. Am. Chem. Soc.*, **116**, 11849-11855 (1994)
(5) Seddon, D. and Whittam, T.V. *E. Patent B-55,529* (1985)
(6) Morimoto, N., Takatsu, K. and Sugimoto, M. *U.S. Patent 4,578,259* (1986)
(7) Gramlich-Meier, R., Gramlich, V. and Meier, W.M. *Am. Mineral.*, **70**, 619-623 (1985)

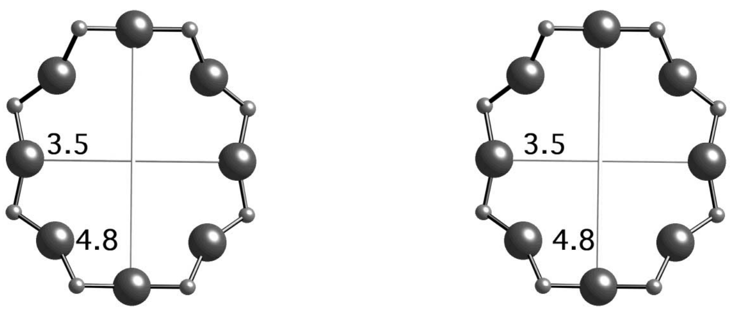
Crystal chemical data: |$Mg^{2+}{}_2Na^{+}{}_2$ $(H_2O)_{18}$| **[**Al_6Si_{30} O_{72}**]-FER**
orthorhombic, Immm, a = 19.156Å, b = 14.127Å, c = 7.489Å [(1)]

Framework density: 17.8 T/1000Å^3

Channels: [001] **10** 4.2 x 5.4* ↔ [010] **8** 3.5 x 4.8*

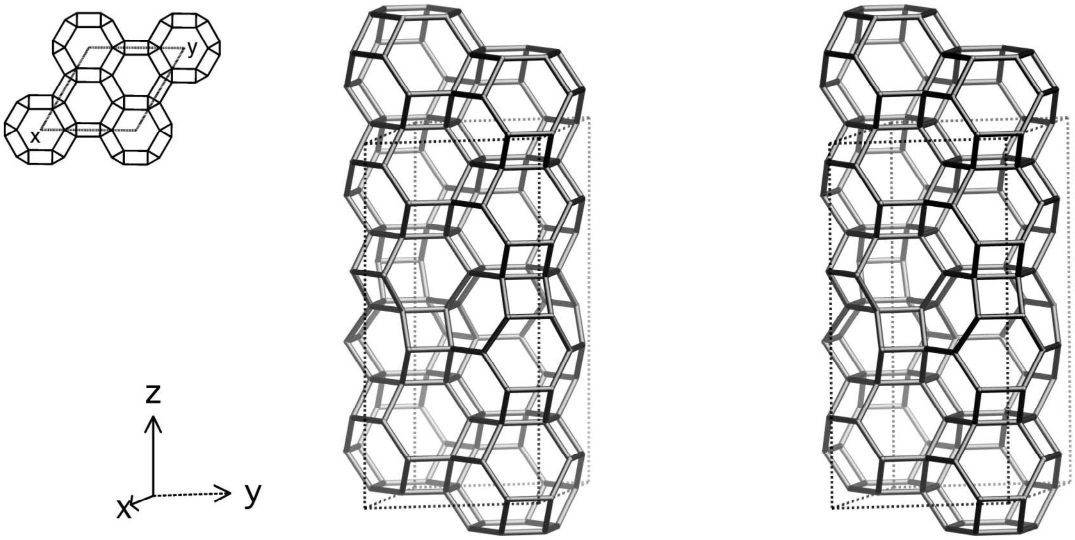


10-ring viewed along [001]



8-ring viewed along [010]

References (cont.):
(8) Whittam, T.V. *E. Patent A-103,981* (1984)
(9) Barrer, R.M. and Marshall, D.J. *J. Chem. Soc.*, 2296-2305 (1964)
(10) Plank, C.J., Rosinski, E.J. and Rubin, M.K. *U.S. Patent 4,016,245* (1977)



framework viewed normal to [001] (top left: projection down [001])

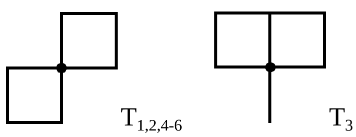
Idealized cell constants: trigonal, P$\bar{3}$m1, a = 12.7Å, c = 25.3Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	10	20	34	52	74	100	130	165	205	4·4·6·6·6·6
T_2 (12, 1)	4	10	20	34	52	74	101	133	168	206	4·4·6·6·6·6
T_3 (12, 1)	4	10	20	34	52	74	101	133	168	206	4·6·4·6·6·6
T_4 (12, 1)	4	10	20	34	53	76	102	132	166	206	4·4·6·6·6·6
T_5 (6, 2)	4	10	20	34	52	74	100	130	164	202	4·4·6·6·6·6
T_6 (6, 2)	4	10	20	34	54	78	104	134	168	208	4·4·6·6·6·6

Secondary building units: 6

Loop configuration of T-Atoms:



Framework description: ABCABACABC sequence of 6-rings

Isotypic framework structures: *Franzinite[1]

References:

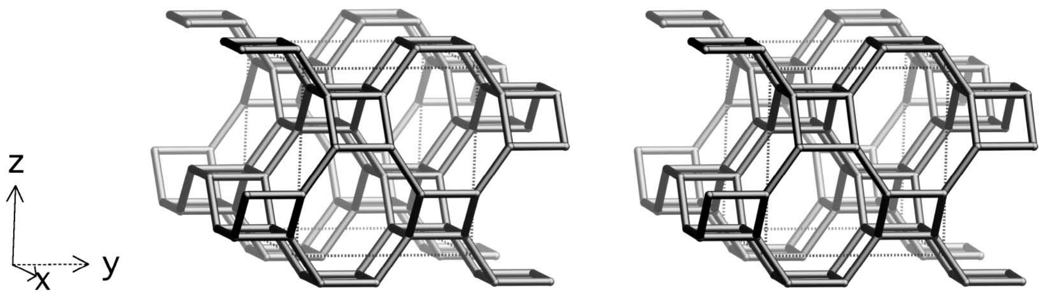
(1) Ballirano, P., Bonaccorsi, E., Maras, A. and Merlino, S. *Can. Mineral.*, **38**, 657-668 (2000)

Crystal chemical data: $|(Na,K)^{+}_{30}\ Ca^{2+}_{10}\ (SO_4)^{2-}_{10}\ (H_2O)_2|$ **[**$Al_{30}Si_{30}\ O_{120}$**]-FRA**
trigonal, P321, a = 12.916Å, c = 26.543Å [(1)]

Framework density: 15.6 T/1000$Å^3$

Channels: apertures formed by 6-rings only

GIS Framework Type $I4_1/amd$



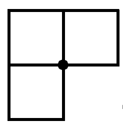
framework viewed along [100]

Idealized cell constants: tetragonal, $I4_1/amd$ (origin choice 2), a = 9.8Å, c = 10.2Å

Coordination sequences and vertex symbols: T_1 (16, 2) 4 9 18 32 48 67 92 120 150 185 $4 \cdot 4 \cdot 4 \cdot 8_2 \cdot 8 \cdot 8$

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



T_1

Isotypic framework structures:

*Gismondine[1]
[Al-Co-P-O**]-GIS**[2]
[Co-Al-P-O**]-GIS**[3]
[Co-Ga-P-O**]-GIS**[4]
[Co-P-O**]-GIS**[5]
[Ga-Si-O**]-GIS**[6]
[Mg-Al-P-O**]-GIS**[3]
[Zn-Ga-P-O**]-GIS**[7]
|$(NH_4)_4$|**[**$Zn_4B_4P_8O_{32}$**]-GIS**[8]
|Cs_4|**[**$Zn_4B_4P_8O_{32}$**]-GIS**[8]
|Rb_4|**[**$Zn_4B_4P_8O_{32}$**]-GIS**[8]
Amicite[9]
Garronite[10,11]
Gobbinsite[12]
High-silica Na-P[13]
Low-silica Na-P (MAP)[14]
MAPO-43[15]
MAPSO-43[16,17]
Na-P1[18]
Na-P2[19]
SAPO-43[20]
Synthetic Ca-garronite[21]
Synthetic amicite[22]
Synthetic garronite[22]
Synthetic gobbinsite[22]
TMA-gismondine[23]

Alternate designation: Gismondite (discredited)
synthetic zeolite B (disused)

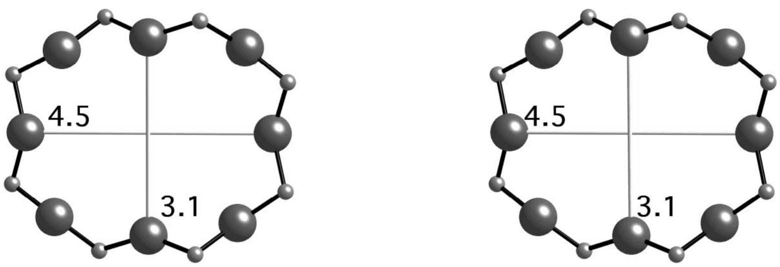
References:

(1) Fischer, K. and Schramm, V. *Adv. Chem. Ser.* , **101**, 250-258 (1971)
(2) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(3) Feng, P., Bu, X., Gier, T.E. and Stucky, G.D. *Microporous and Mesoporous Materials*, **23**, 221-229 (1998)
(4) Cowley, A.R. and Chippindale, A.M. *Chem. Commun.*, 673-674 (1996)
(5) Yuan, H.M., Chen, J.S., Zhu, G.S.,Li, J.Y., Yu, J.H., Yang, G.D. and Xu, R. *Inorg. Chem.*, **39**, 1476-1479 (2000)

Crystal chemical data: **|**Ca^{2+}_4 $(H_2O)_{16}$**|** **[**Al_8Si_8 O_{32}**]-GIS**
monoclinic, $P112_1/a$
a = 9.843Å, b = 10.023Å, c = 10.616Å, γ= 92.417° (1)
(Relationship to unit cell of Framework Type: a' = a, b' = b, c' = c)

Framework density: 15.3 T/1000$Å^3$

Channels: {[100] **8** 3.1 x 4.5 ↔ [010] **8** 2.8 x 4.8}*** (variable due to considerable flexibility of the framework)



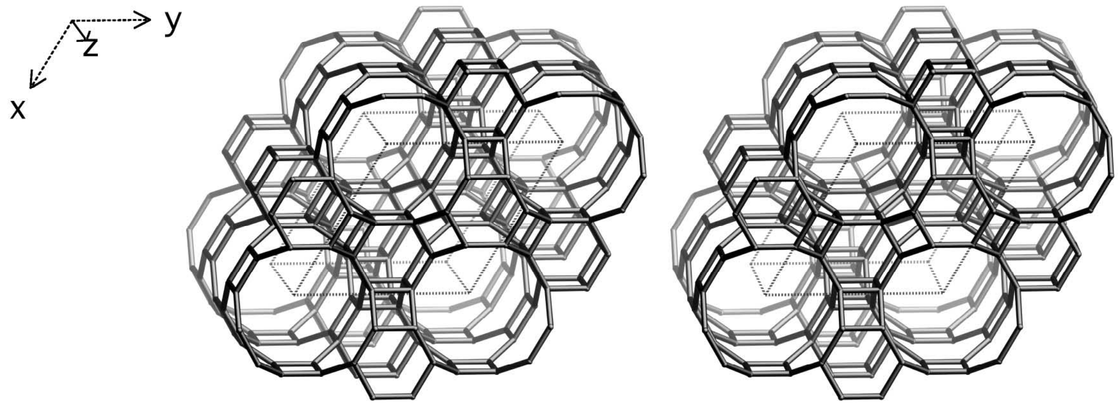
8-ring viewed along [100]

See Appendix A for 8-ring viewed along [010]

References (cont.):

(6) Cho, H.H., Kim, S.H., Kim, Y.G., Kim, Y.C., Koller, H., Camblor, M.A. and Hong, S.B. *Chem. Mater.*, **12**, 2292-2300 (2000)
(7) Chippindale, A.M., Cowley, A.R. and Peacock, K.J. *Microporous and Mesoporous Materials*, **24**, 133-141 (1998)
(8) Kniep, R., Schäfer, G., Engelhardt, H. and Boy, I. *Angew. Chem. Int. Ed.*, **38**, 3642-3644 (1999)
(9) Alberti, A. and Vezzalini, G. *Acta Crystallogr.*, **B35**, 2866-2869 (1979)
(10) Artioli, G. *Am. Mineral.*, **77**, 189-196 (1992)
(11) Artioli, G. and Marchi, M. *Powder Diffraction*, **14**, 190-194 (1999)
(12) McCusker, L.B., Baerlocher, Ch. and Nawaz, R. *Z. Kristallogr.*, **171**, 281-289 (1985)
(13) Håkansson, U., Fälth, L. and Hansen, S. *Acta Crystallogr.*, **C46**, 1363-1364 (1990)
(14) Albert, B.R., Cheetham, A.K., Stuart, J.A. and Adams, C.J. *Microporous and Mesoporous Materials*, **21**, 133-142 (1998)
(15) Pluth, J.J., Smith, J.V. and Bennett, J.M. *J. Am. Chem. Soc.*, **111**, 1692-1698 (1989)
(16) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. *Pure Appl. Chem.*, **58**, 1351-1358 (1986)
(17) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo
(18) Baerlocher, Ch. and Meier, W.M. *Z. Kristallogr.*, **135**, 339-354 (1972)
(19) Hansen, S., Håkansson, U. and Fälth, L. *Acta Crystallogr.*, **C46**, 1361-1362 (1990)
(20) Helliwell, M., Kaucic, V., Cheetham, G.M.T., Harding, M.M., Kariuki, B.M. and Rizkallah, P.J. *Acta Crystallogr.*, **B49**, 413-420 (1993)
(21) Schropfer, L and Joswig, W. *Eur. J. Mineral.*, **9**, 53-65 (1997)
(22) Ghobarkar, H. and Schaef, O. *Mater. Res. Bull.*, **34**, 517-525 (1999)
(23) Baerlocher, Ch. and Meier, W.M. *Helv. Chim. Acta*, **53**, 1285-1293 (1970)

GME Framework Type $P6_3/mmc$



framework viewed along [001]

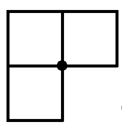
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 13.7Å, c = 9.9Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	29	45	65	89	116	144	175		4·4·4·8·6·8

Secondary building units: 6-6 or 8 or 4-2 or 6 or 4

Loop configuration of T-Atoms:



T_1

Framework description: AABB sequence of 6-rings

Isotypic framework structures:
*Gmelinite[1]
K-rich gmelinite[2]
Synthetic fault-free gmelinite[3]

Alternate designation: sarcolite (discredited)

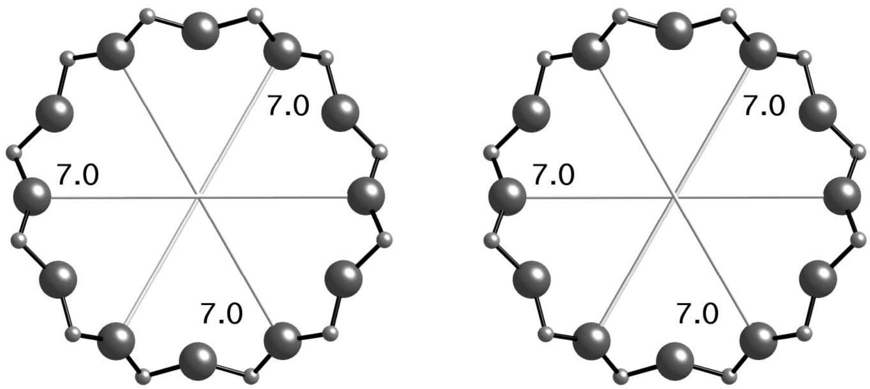
References:
(1) Fischer, K. *N. Jb. Miner. Mh.*, 1-13 (1966)
(2) Vezzalini, G., Quartieri, S. and Passaglia, E. *N. Jb. Miner. Mh.*, 504-516 (1990)
(3) Daniels, R.H., Kerr, G.T. and Rollmann, L.D. *J. Am. Chem. Soc.*, **100**, 3097-3100 (1978)

Gmelinite **Type Material** **GME**

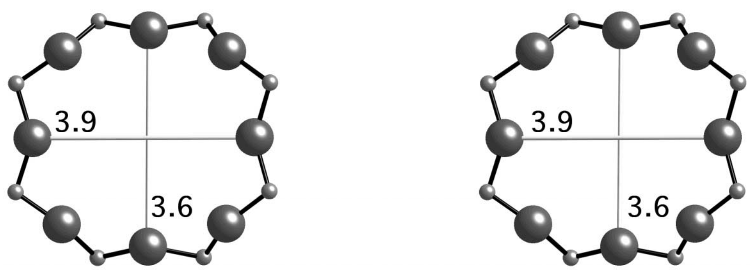
Crystal chemical data: **|**$(Ca^{2+},Na^{+}_{2})_4\ (H_2O)_{24}$**|** **[**$Al_8Si_{16}\ O_{48}$**]-GME**
hexagonal, $P6_3/mmc$, a = 13.75Å, c = 10.05Å [(1)]

Framework density: 14.6 T/1000Å^3

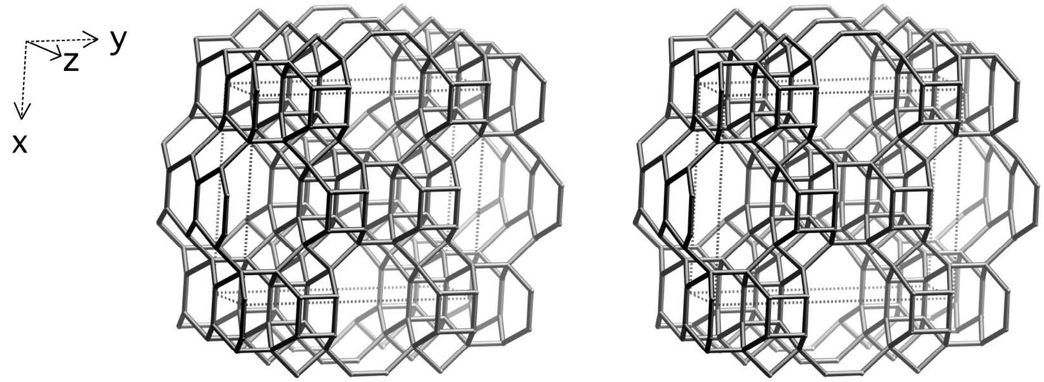
Channels: [001] **12** 7.0 x 7.0* ↔ ⊥ [001] **8** 3.6 x 3.9**



12-ring viewed along [001]



8-ring viewed normal to [001]



framework viewed along [001]

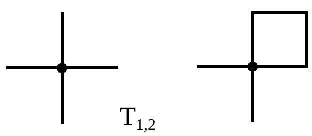
Idealized cell constants: orthorhombic, Cmmm, a = 16.9Å, b = 20.4Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	12	21	39	63	85	117	154	192	242	$5\cdot6\cdot5\cdot6\cdot5_2\cdot6$
T_2 (8, 1)	4	12	25	38	57	86	119	158	194	233	$5\cdot6\cdot5\cdot6\cdot6\cdot12_6$
T_3 (8, 1)	4	11	22	38	58	86	121	156	191	229	$4\cdot6_2\cdot5\cdot6\cdot5\cdot6$
T_4 (8, 1)	4	11	22	38	63	91	115	147	195	244	$4\cdot6_2\cdot5\cdot6\cdot5\cdot6$

Secondary building units: 5-3

Loop configuration of T-Atoms:



$T_{1,2}$ $T_{3,4}$

Isotypic framework structures: *GUS-1[1]

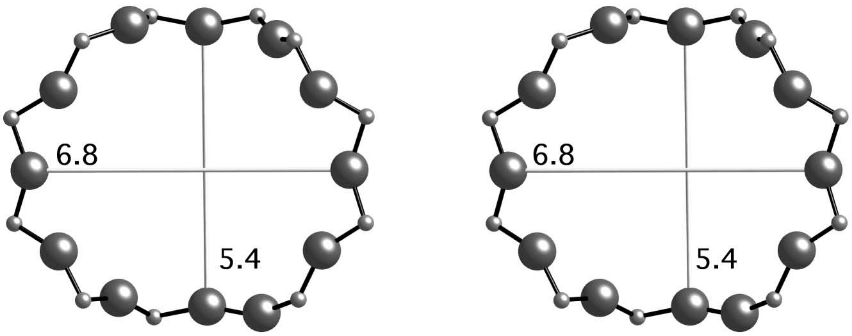
References:

(1) Plévert, J., Kubota, Y., Honda, T., Okubo, T. and Sugi, Y. *Chem. Commun.*, 2363-2364 (2000)

Crystal chemical data: **[**Si_{32} O_{64}**]-GON**
orthorhombic, C222, a = 16.421Å, b = 20.054Å, c = 5.046Å [1]

Framework density: 19.3 T/1000Å^3

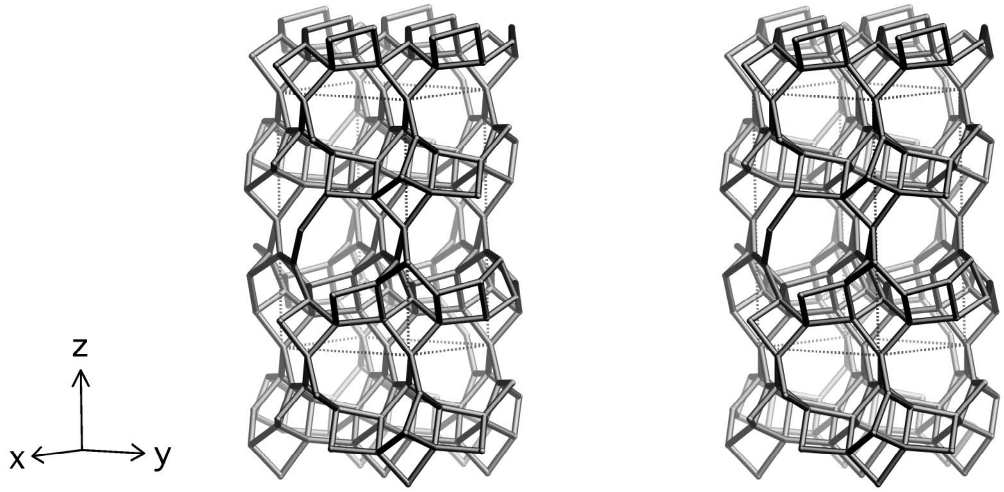
Channels: [001] **12** 5.4 x 6.8*



12-ring viewed along [001]



8-ring viewed along [001]



framework viewed along [110]

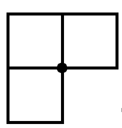
Idealized cell constants: orthorhombic, $C222_1$, a = 8.7Å, b = 11.0Å, c = 17.5Å

Coordination sequences and vertex symbols:

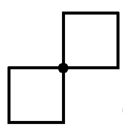
T_1 (8, 1)	4	9	19	36	56	80	102	132	180	220	$4\cdot4\cdot4\cdot8_3\cdot6_2\cdot8_2$
T_2 (8, 1)	4	10	20	36	55	77	108	140	174	219	$4\cdot4\cdot6\cdot8_3\cdot6_3\cdot8_2$
T_3 (8, 1)	4	9	19	36	56	76	106	142	172	217	$4\cdot4\cdot4\cdot8_2\cdot6\cdot8_2$
T_4 (4, 2)	4	10	20	34	58	82	102	136	176	220	$4\cdot4\cdot6_4\cdot8_4\cdot8_2\cdot8_2$
T_5 (4, 2)	4	10	20	34	52	78	110	140	176	212	$4\cdot4\cdot8_2\cdot10_6\cdot8_3\cdot8_3$

Secondary building units: 6-2

Loop configuration of T-Atoms:



$T_{1,3}$



$T_{2,4,5}$

Isotypic framework structures: *Goosecreekite[1]

References:

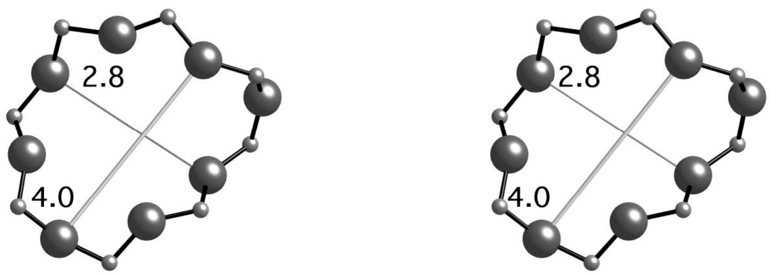
(1) Rouse, R.C. and Peacor, D.R. *Am. Mineral.*, **71**, 1494-1501 (1986)

Goosecreekite Type Material GOO

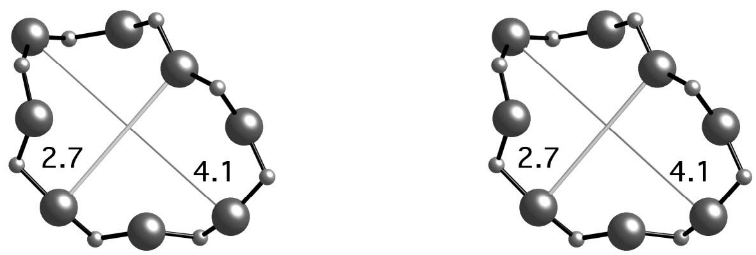
Crystal chemical data: |Ca^{2+}_2 $(H_2O)_{10}$| **[**Al_4Si_{12} O_{32}**]-GOO**
monoclinic, $P12_11$, a = 7.401Å, b = 17.439Å, c = 7.293Å, β = 105.44° (1)
(Relationship to unit cell of Framework type:
a' = a/2cos(β'/2), b' = c, c' = a/2cos(β'/2)
or, as vectors, **a**' = (**a** + **b**)/2, **b**' = **c**, **c**' = (**a** - **b**)/2)

Framework density: 17.6 T/1000Å^3

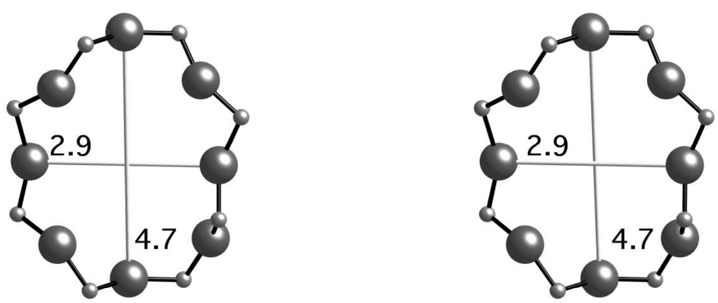
Channels: [100] **8** 2.8 x 4.0* ↔ [010] **8** 2.7 x 4.1* ↔ [001] **8** 2.9 x 4.7*



8-ring viewed along [100]

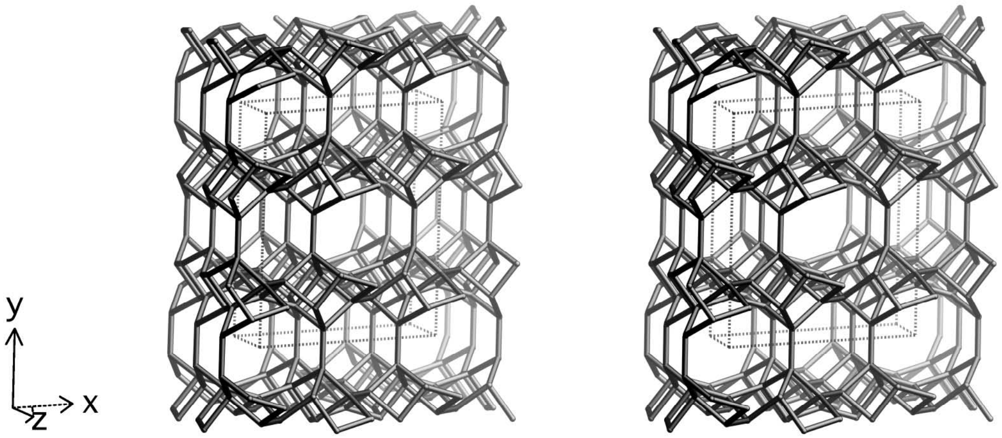


8-ring viewed along [010]



8-ring viewed along [001]

HEU   Framework Type   C2/m



framework viewed along [001]

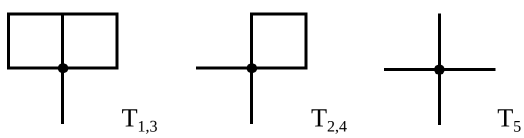
Idealized cell constants: monoclinic, C2/m, a = 17.5Å, b = 17.6Å, c = 7.4Å, β = 116.1°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	20	34	62	85	104	148	201	241	4·5·4·5·5·8
T_2 (8, 1)	4	11	23	39	55	82	127	158	178	221	4·8·5·8·5·8
T_3 (8, 1)	4	10	19	37	58	84	109	149	201	236	4·5·4·8·5·5
T_4 (8, 1)	4	11	21	35	61	89	111	146	194	243	4·5·5·5·5·8
T_5 (4, 2)	4	12	18	34	62	88	110	132	196	254	$5\cdot5\cdot5_2\cdot5_2\cdot10\cdot10$

Secondary building units: 4-4=1

Loop configuration of T-Atoms:



Isotypic framework structures:
*Heulandite[1,2]
Clinoptilolite[3]
Dehydrated Ca,NH_4-Heulandite[4]
LZ-219[5]

Alternate designation: stilbite (mistake in older literature)

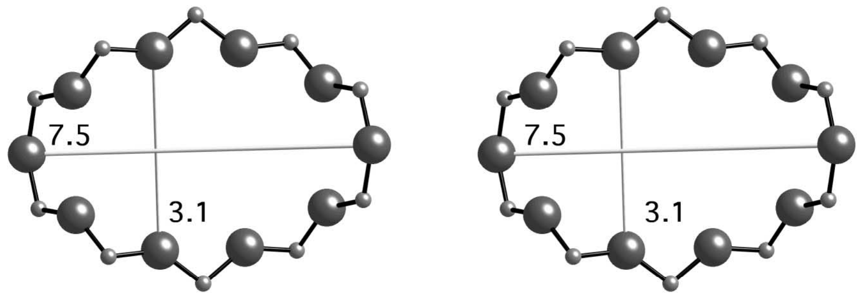
References:

(1) Merkle, A.B. and Slaughter, M. *Am. Mineral.*, **52**, 273-276 (1967)
(2) Alberti, A. *Tschermaks Min. Petr. Mitt.*, **18**, 129-146 (1972)
(3) Koyama, K. and Takeuchi, Y. *Z. Kristallogr.*, **145**, 216-239 (1977)
(4) Mortier, W.J. and Pearce, J.R. *Am. Mineral.*, **66**, 309-314 (1981)
(5) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)

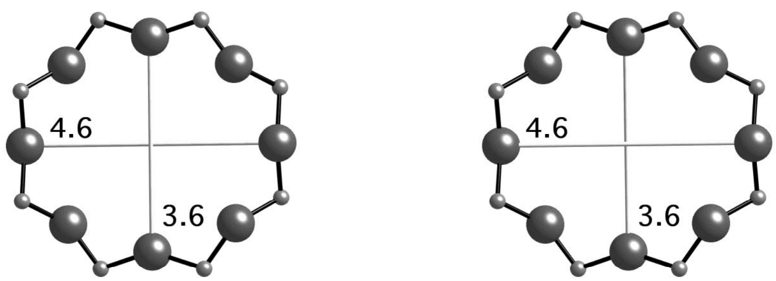
Crystal chemical data: |Ca^{2+}_4 $(H_2O)_{24}$| [Al_8Si_{28} O_{72}]-**HEU**
monoclinic, Cm, a = 17.718Å, b = 17.897Å, c = 7.428Å, β = 116.42° (2)

Framework density: 17.1 T/1000Å^3

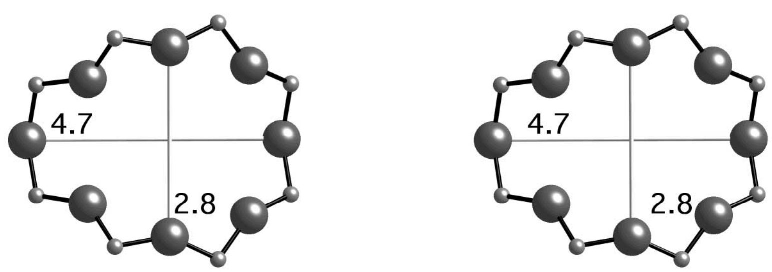
Channels: {[001] **10** 3.1 x 7.5* + **8** 3.6 x 4.6*} ↔ [100] **8** 2.8x 4.7* (variable due to considerable flexibility of the framework)



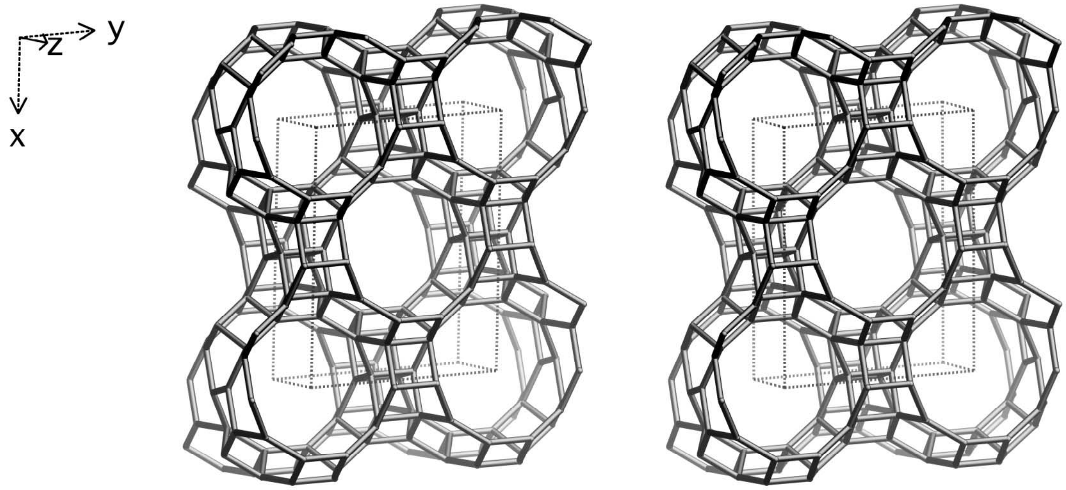
10-ring viewed along [001]



8-ring, also along [001]



8-ring viewed along [100]



framework viewed along [001]

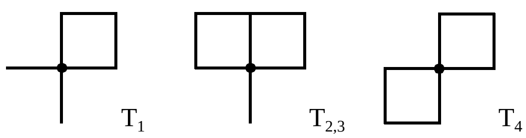
Idealized cell constants: monoclinic, C2/m, a = 18.6Å, b = 13.4Å, c = 7.6Å, β = 102.3°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	20	32	53	77	100	135	166	199	$4·6_2·5·6·6·12_3$
T_2 (8, 1)	4	10	18	31	52	77	103	127	159	210	$4·5·4·6·5·6_2$
T_3 (8, 1)	4	10	19	32	53	78	102	126	162	209	$4·6·4·6·5·6_2$
T_4 (8, 1)	4	10	21	35	50	74	105	133	165	206	$4·4·5·12_5·6·6_2$

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures:
*ITQ-4[(1)]
MCM-58[(2)]
SSZ-42[(3)]

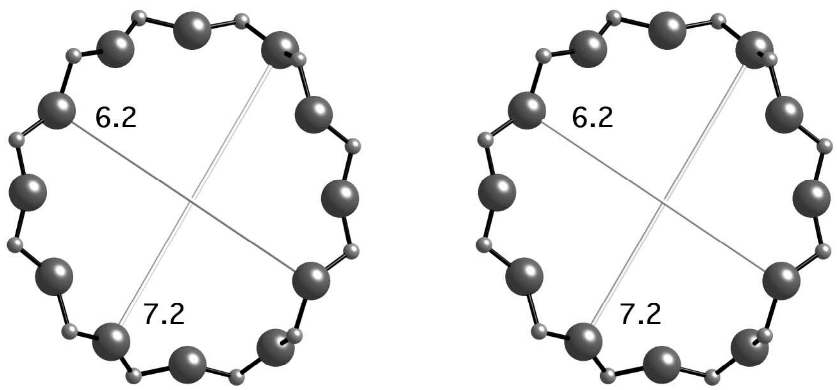
References:

(1) Barrett, P.A., Camblor, M.A., Corma, A., Jones, R.H. and Villaescusa, L.A. *Chem. Mater.*, **9**, 1713-1715 (1997)
(2) Valyocsik, E.W. *WOP 9511196* (1995)
(3) Chen, C.Y., Finger, L.W., Medrud, R.C., Crozier, P.A., Chan, I.Y., Harris, T.V. and Zones, S.I. *Chem. Commun.*, 1775-1776 (1997)

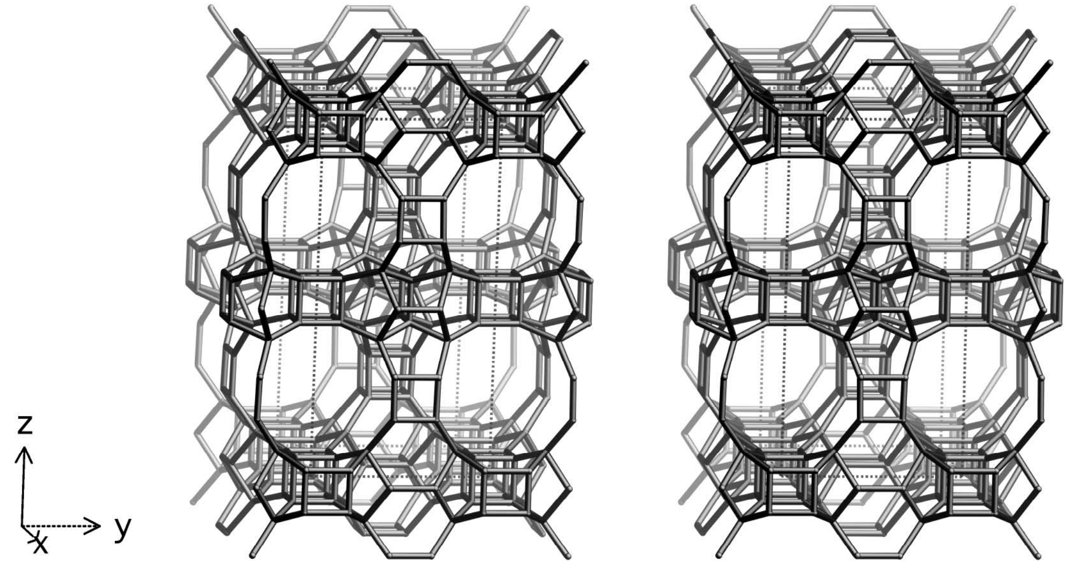
Crystal chemical data: **[**Si_{32} O_{64}**]-IFR**
monoclinic, I12/m1
a = 18.652Å, b = 13.496Å, c = 7.631Å, β = 101.98° [(1)]
(Relationship to unit cell of Framework Type:
as vectors, **a'** = **a** + **c**, **b**' = **b**, **c**' = **-c**)

Framework density: 17 T/1000$Å^3$

Channels: [001] **12** 6.2 x 7.2*



12-ring viewed along [001]



framework viewed along [100]

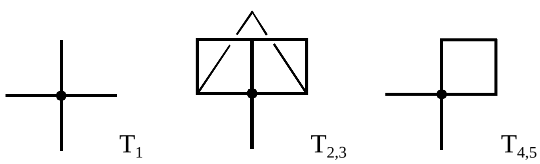
Idealized cell constants: tetragonal, $P4_2/mmc$, a = 12.9Å, c = 25.7Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	12	17	30	48	72	99	128	160	199	$5\cdot5\cdot5_2\cdot12_5\cdot6\cdot6$
T_2 (16, 1)	4	9	18	32	50	71	96	129	167	200	$4\cdot5\cdot4\cdot6\cdot4\cdot12_7$
T_3 (16, 1)	4	9	18	32	50	72	97	128	167	203	$4\cdot5\cdot4\cdot6\cdot4\cdot12_4$
T_4 (8, m)	4	11	20	28	42	74	110	132	150	195	$4\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_5 (8, m)	4	11	20	28	41	70	105	131	154	188	$4\cdot5_2\cdot5\cdot6\cdot5\cdot6$

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures: *ITQ-7[1]

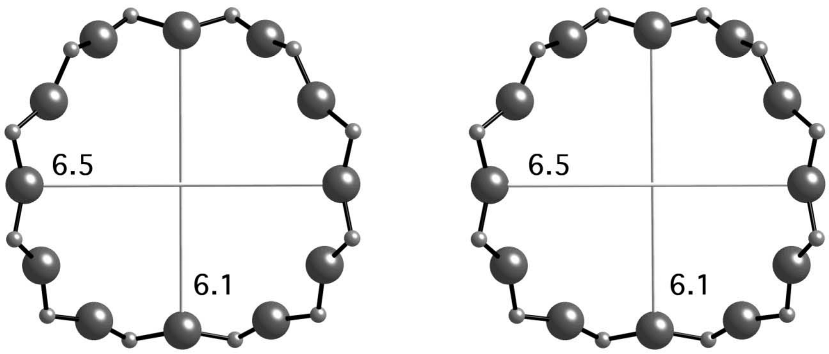
References:

(1) Villaescusa, L.A., Barrett, P.A. and Camblor, M.A. *Angew. Chem., Int. Ed.*, **38**, 1997-2000 (1999)

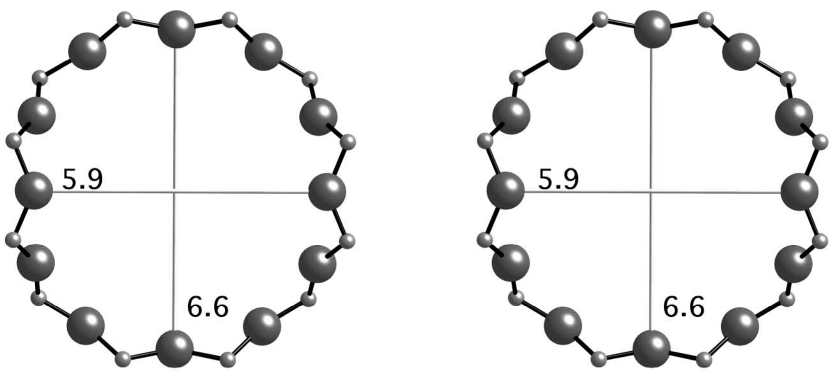
Crystal chemical data: **[**Si_{64} O_{128}**]-ISV**
tetragonal, $P4_2/mmc$, a = 12.853 Å, c = 25.214Å [(1)]

Framework density: 15.4 T/1000Å^3

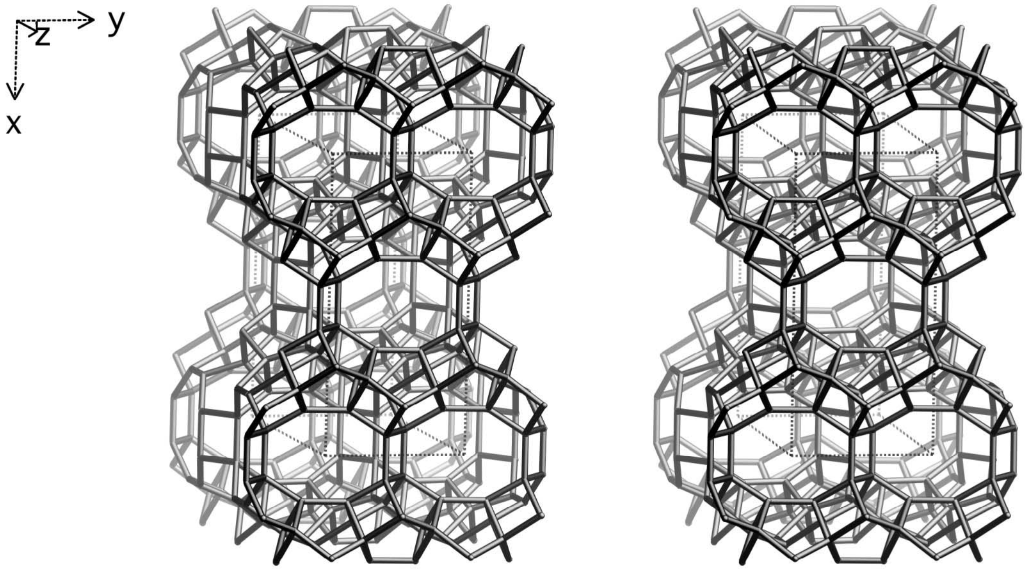
Channels: <100> **12** 6.1 x 6.5** ↔ [001] **12** 5.9 x 6.6*



12-ring viewed along <100>



12-ring viewed along [001]



framework viewed along [001]

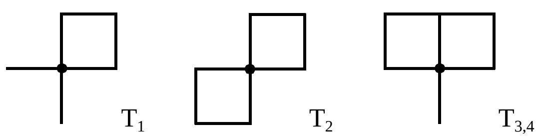
Idealized cell constants: orthorhombic, Cmcm, a = 20.8Å, b = 9.8Å, c = 20.0Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	21	34	53	78	108	138	168	211	4·6·5·6·5·8
T_2 (16, 1)	4	10	21	36	54	77	102	135	181	217	4·4·5·8·5·8
T_3 (16, 1)	4	10	19	31	50	82	107	132	168	209	4·5·4·6·5·5
T_4 (16, 1)	4	10	18	31	55	77	105	136	166	216	4·5·4·8·5·5

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *ITQ-3[1]

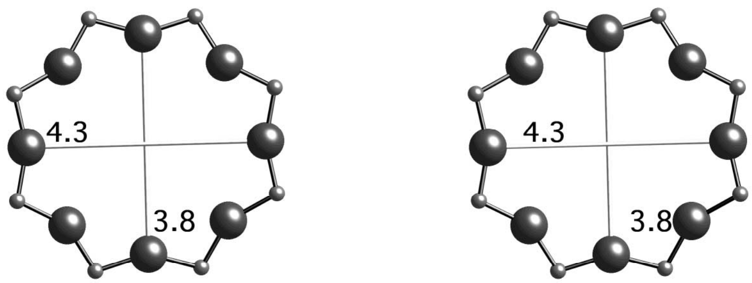
References:

(1) Camblor, M.A., Corma, A., Lightfoot, P., Villaescusa, L.A. and Wright, P.A. *Angew. Chem., Int. Ed.*, **36**, 2659-2661 (1997)

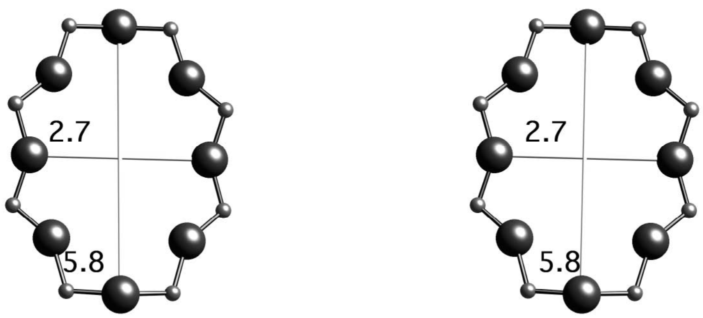
Crystal chemical data: **[**Si_{64} O_{128}**]-ITE**
orthorhombic, Cmcm, a = 20.622Å, b = 9.724Å, c = 19.623Å [(1)]

Framework density: 16.3 T/1000$Å^3$

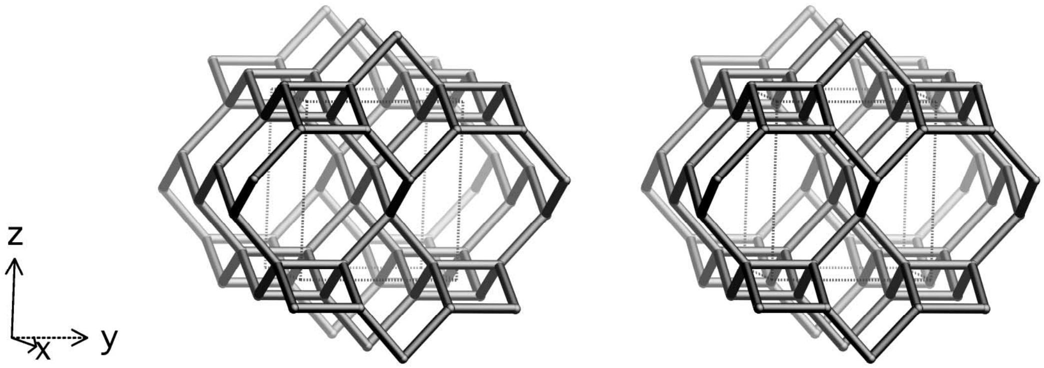
Channels: [010] **8** 3.8 x 4.3* ↔ [001] **8** 2.7 x 5.8*



8-ring viewed along [010]



8-ring viewed along [001]



framework viewed along [100]

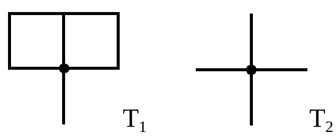
Idealized cell constants: orthorhombic, Pmma, a = 5.3Å, b = 7.5Å, c = 8.2Å

Coordination sequences and vertex symbols:

T_1 (4, m)	4	10	21	39	61	81	107	148	192	228	$4 \cdot 6_2 \cdot 4 \cdot 6_2 \cdot 6 \cdot 8_2$
T_2 (2, mm2)	4	12	24	36	56	86	118	146	176	228	$6 \cdot 6 \cdot 6 \cdot 6 \cdot 6_2 \cdot 6_2$

Secondary building units: 6

Loop configuration of T-Atoms:



Isotypic framework structures:
*Na-J (Barrer and White)[1]
Nepheline hydrate[2] (not related to nepheline)
Synthetic **|**Na-**|[**Al-Si-O**]-JBW**[3]

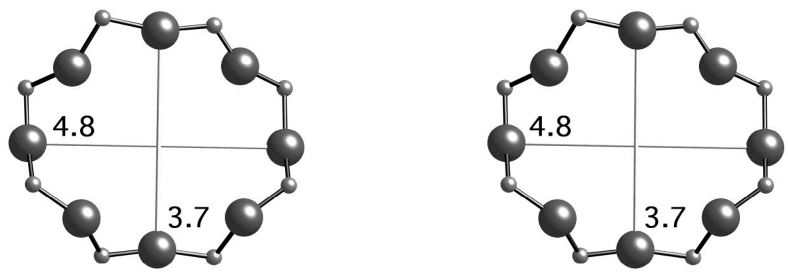
References:

(1) Hansen, S. and Fälth, L. *Zeolites*, **2**, 162-166 (1982)
(2) Rheinhardt, A., Hellner, E. and Ahsbahs, H. *Fortsch. Mineral.*, **60**, 175-176 (1982)
(3) Ragimov, K.G., Chiragove, M.I., Mustafaev, N.M. and Mamedov, Kh.S. *Sov. Phys. Dokl.*, **23**, 697-698 (1978)

Crystal chemical data: |Na^+_3 $(H_2O)_{1.5}$| [Al_3Si_3 O_{12}]-**JBW**
orthorhombic, $Pna2_1$, a = 16.426Å, b = 15.014Å, c = 5.224Å [(1)]
(Relationship to unit cell of Framework Type: a' = 2c, b' = 2b, c' = a)

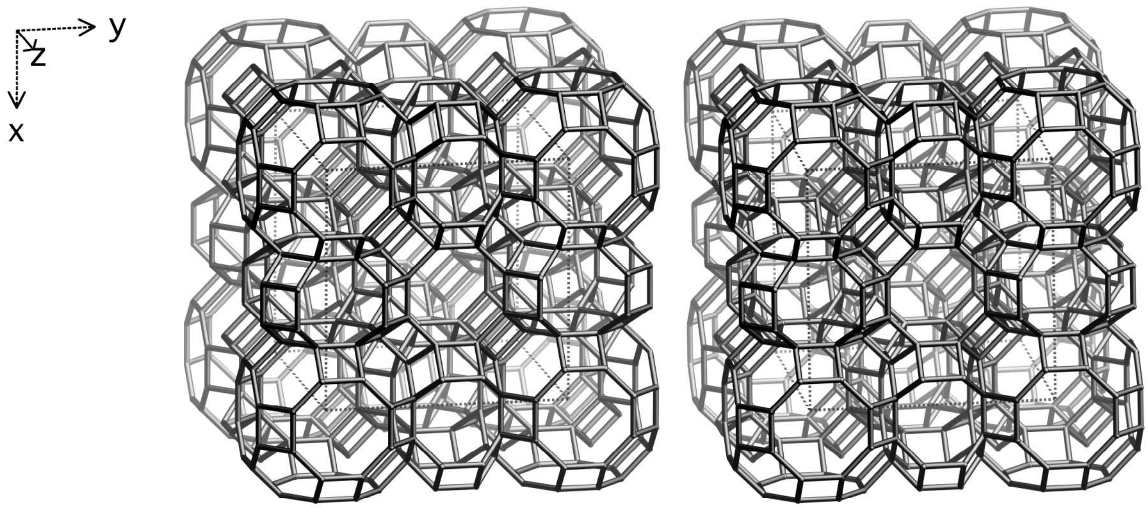
Framework density: 18.6 T/1000Å^3

Channels: [001] **8** 3.7 x 4.8*



8-ring along [001]

KFI Framework Type $Im\bar{3}m$



framework viewed along [001]

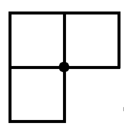
Idealized cell constants: cubic, $Im\bar{3}m$, a = 18.6Å

Coordination sequences and vertex symbols:

T_1 (96, 1)	4	9	17	29	45	64	86	112	141	173	4·4·4·8·6·8

Secondary building units: 6-6 or 6-2 or 8 or 6 or 4

Loop configuration of T-Atoms:



T_1

Isotypic framework structures:

*ZK-5[1]
(Cs,K)-ZK-5[2.3]
P[4]
Q[4]

References:

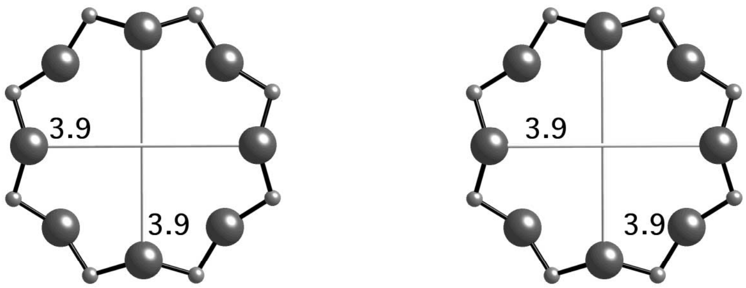
(1) Meier, W.M. and Kokotailo, G.T. *Z. Kristallogr.*, **121**, 211-219 (1965)
(2) Robson, H.E. *U.S. Patent 3,720,753* (1973)
(3) Parise, J.B., Shannon, R.D., Prince, E. and Cox, D.E. *Z. Kristallogr.*, **165**, 175-190 (1983)
(4) Barrer, R.M. and Robinson, D. *Z. Kristallogr.*, **135**, 374-390 (1972)

ZK-5 — Type Material — KFI

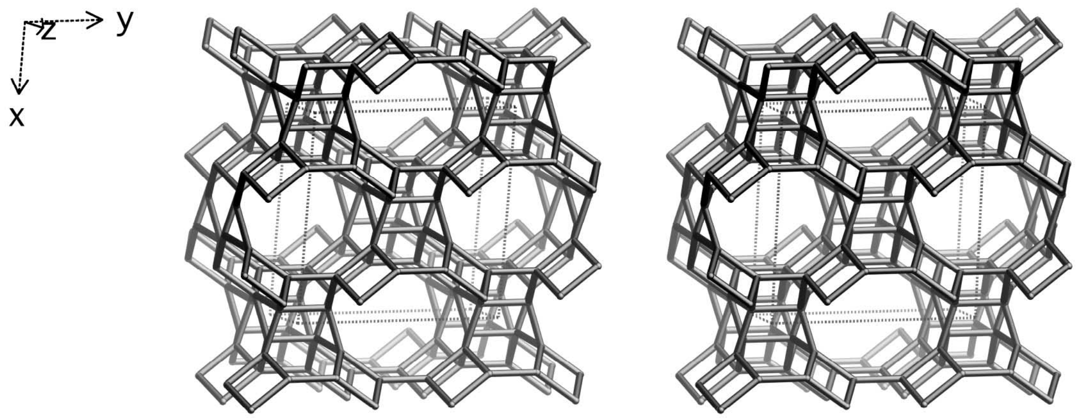
Crystal chemical data: **|**Na^{+}_{30} $(H_2O)_{98}$**|** **[**$Al_{30}Si_{66}$ O_{192}**]-KFI**
cubic, $Im\overline{3}m$, a = 18.75Å [(1)]

Framework density: 14.6 T/1000$Å^3$

Channels: <100> **8** 3.9 x 3.9*** | <100> **8** 3.9 x 3.9***



8-ring viewed along <100>



framework viewed along [001]

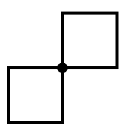
Idealized cell constants: monoclinic, C2/m, a = 14.6Å, b = 12.9Å, c = 7.6Å, β = 111.2°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	20	33	51	74	99	128	161	199	$4\cdot4\cdot6\cdot6_2\cdot6\cdot10_4$
T_2 (8, 1)	4	10	19	32	52	74	99	126	162	203	$4\cdot4\cdot6\cdot6_2\cdot6\cdot10_2$
T_3 (8, 1)	4	10	19	33	53	74	96	127	166	201	$4\cdot4\cdot6\cdot6_3\cdot6\cdot6_3$

Secondary building units: 6-2 or 6

Loop configuration of T-Atoms:



T_{1-3}

Isotypic framework structures:

*Laumontite[1-4]
[Co-Ga-P-O**]-LAU**[5,6]
[Fe-Ga-P-O**]-LAU**[6]
[Mn-Ga-P-O**]-LAU**[6]
Synthetic laumontite[8]

Alternate designation: Leonhardite[7] (discredited)

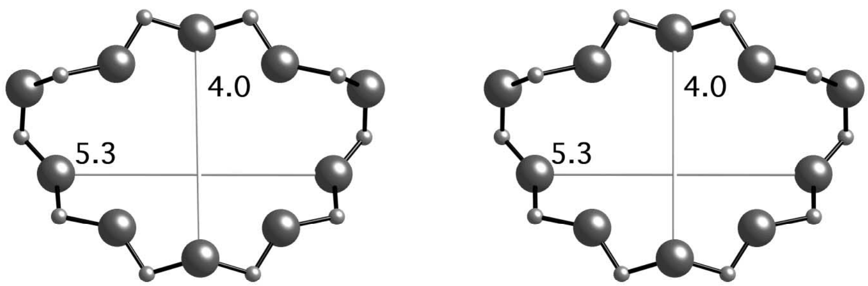
References:

(1) Bartl, H. and Fischer, K. *N. Jb. Miner. Mh.*, 33-42 (1967)
(2) Amirov, S.T., Ilyukhin, V.V. and Belov, N.V. *Dokl. Akad. Nauk SSSR*, **174**, 667- (1967)
(3) Schramm, V. and Fischer *Adv. Chem. Ser.* , **101**, 259-265 (1971)
(4) Artioli, G. and Ståhl, K. *Zeolites*, **17**, 249-255 (1993)
(5) Chippindale, A.M. and Walton, R.I. *Chem. Commun.*, 2453-2454 (1994)
(6) Bond, A.D., Chippindale, A., Cowley, A.R., Readman, J.E. and Powell, A.V. *Zeolites*, **19**, 326-333 (1997)
(7) Lapham, D.L. *Am. Mineral.*, **48**, 683-689 (1963)
(8) Ghobarkar, H. and Schaef, O. *Microporous and Mesoporous Materials*, **23**, 55-60 (1998)

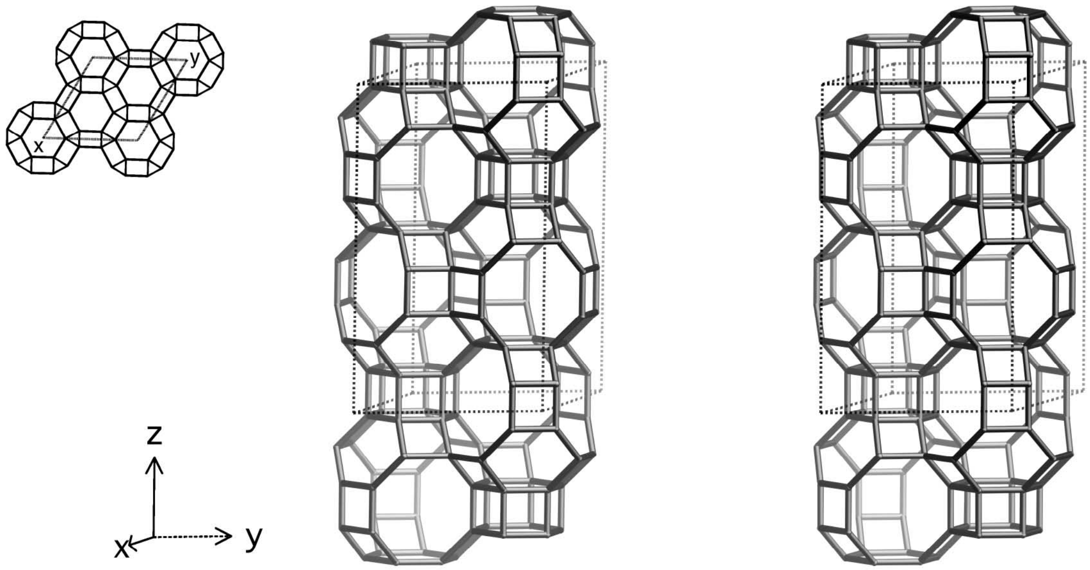
Crystal chemical data: |Ca^{2+}_4 $(H_2O)_{16}$| **[**Al_8Si_{16} O_{48}**]-LAU**
monoclinic, Am, a = 7.549Å, b = 14.740Å, c = 13.072Å, γ= 111.9° (3)
(Relationship to unit cell of Framework Type: a' = c, b' = a, c' = b, γ' = β)

Framework density: 17.8 T/1000Å^3

Channels: [100] **10** 4.0 x 5.3* (contracts upon dehydration)



10-ring viewed along [100]



framework viewed normal to [001] (top left: projection down [001])

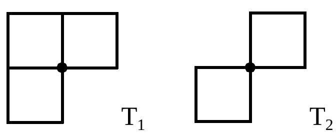
Idealized cell constants: trigonal, $R\bar{3}m$, a = 13.2Å, c = 22.6Å

Coordination sequences and vertex symbols:

T_1 (36, 1)	4	9	17	30	49	71	92	114	143	183	4·4·4·6·6·8
T_2 (18, 2)	4	10	20	32	46	64	90	124	156	184	4·4·6·6·8·8

Secondary building units: 6

Loop configuration of T-Atoms:



Framework description: AABCCABBC sequence of 6-rings

Isotypic framework structures:
*Levyne[1,2]
AlPO-35[3]
CoDAF-4[4]
LZ-132[5]
NU-3[6]
SAPO-35[7]
ZK-20[8]

Alternate designation: Levynite (obsolete)

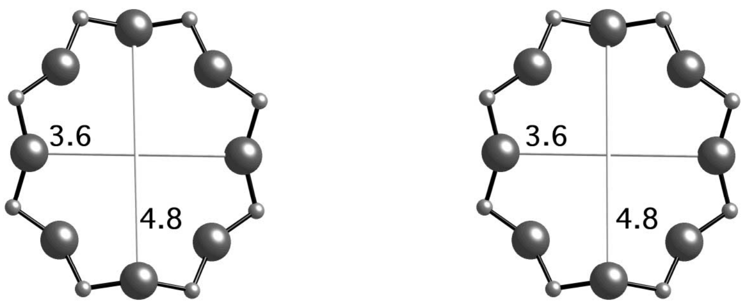
References:

(1) Barrer, R.M. and Kerr, I.S. *Trans. Faraday Soc.*, **55**, 1915-1923 (1959)
(2) Merlino, S., Galli, E. and Alberti, A. *Tschermaks Min. Petr. Mitt.*, **22**, 117-129 (1975)
(3) Zhu, G.S., Xiao, F.S., Qiu, S.L., Hun, P.C., Xu, R.R., Ma, S.J. and Terasaki, O. *Microporous Materials*, **11**, 269-273 (1997)
(4) Barrett, P.A. and Jones, R.H. *Phys. Chem. Chem. Phys.*, **2**, 407-412 (2000)

Crystal chemical data: |Ca^{2+}_9 $(H_2O)_{50}$| [$Al_{18}Si_{36}$ O_{108}]-**LEV**
trigonal, $R\overline{3}m$, a = 13.338Å, c = 23.014Å [2]

Framework density: 15.2 T/1000$Å^3$

Channels: ⊥ [001] **8** 3.6 x 4.8**



8-ring viewed normal to [001]

References (cont.):

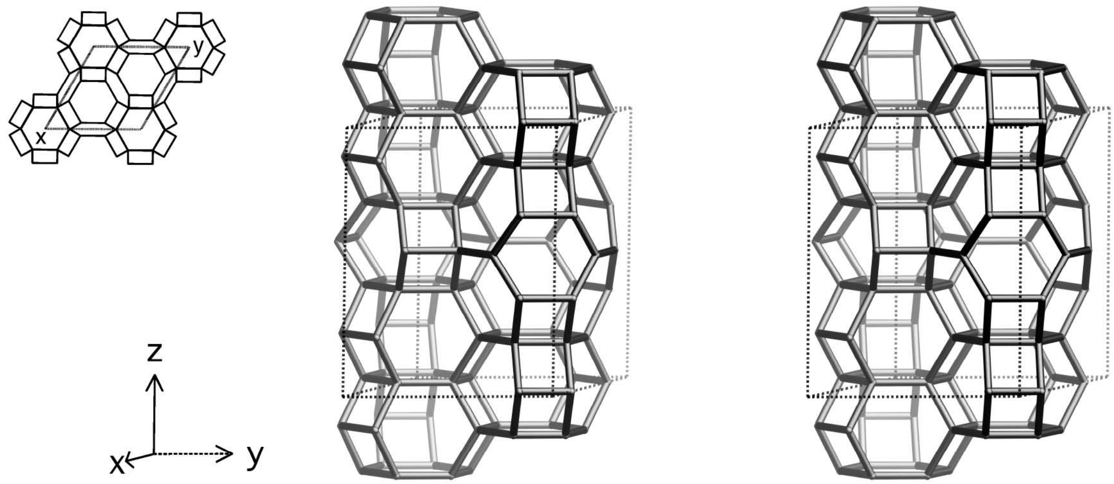
(5) Tvaruzkova, Z., Tupa, M., Kiru, P., Nastro, A., Giordano, G. and Trifiro, F. *Int. Zeolite Sym., Wurzburg, Extended Abstracts* (1988)

(6) McCusker, L.B. *Mater. Sci. Forum*, **133-136**, 423-433 (1993)

(7) Lok, B.M., Messina, C.A., Patton, R.L., Gajek, R.T., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **106**, 6092-6093 (1984)

(8) Kerr, G.T. *U.S. Patent 3,459,676* (1969)

LIO Framework Type P$\bar{6}$m2



framework viewed normal to [001] (top left: projection down [001])

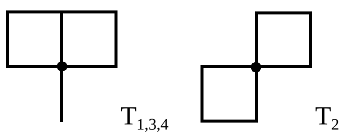
Idealized cell constants: hexagonal, P$\bar{6}$m2, a = 12.3Å, c = 15.6Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	10	20	34	53	76	103	135	170	209	4·6·4·6·6·6
T_2 (12, 1)	4	10	20	34	54	78	104	134	168	210	4·4·6·6·6·6
T_3 (6, m)	4	10	20	34	52	74	102	136	172	208	4·6·4·6·6·6
T_4 (6, m)	4	10	20	34	54	78	104	134	168	210	4·6·4·6·6·6

Secondary building units: 6

Loop configuration of T-Atoms:



Framework description: ABABAC sequence of 6-rings

Isotypic framework structures: *Liottite[1,2]

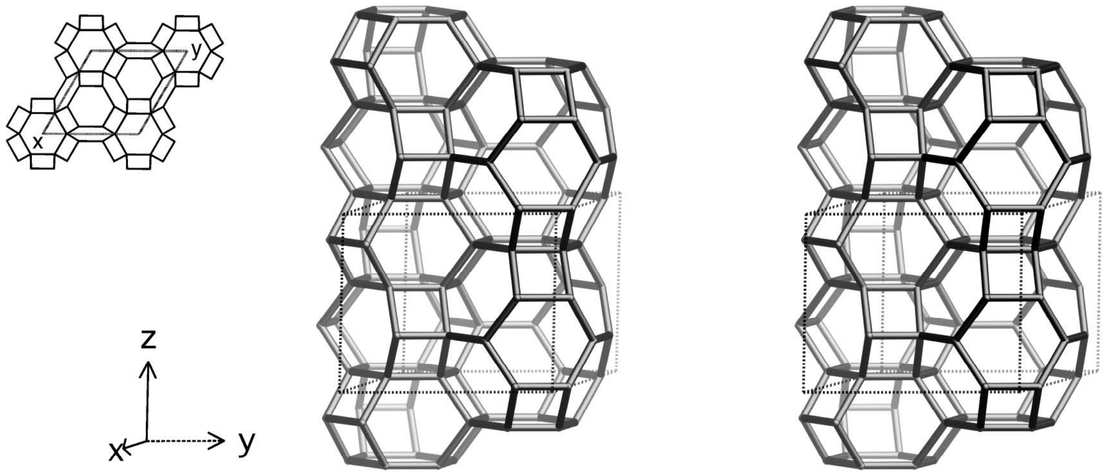
References:

(1) Merlino, S. and Orlandi, P. *Am. Mineral.*, **62**, 321-326 (1977)
(2) Ballirano, P., Merlino, S. and Bonaccorsi, E. *Can. Mineral.*, **34**, 1021-1030 (1996)

Crystal chemical data: |$Ca^{2+}_8(K^+,Na^+)_{16}(SO_4^{2-})_5Cl^-_4$| [$Al_{18}Si_{18}O_{72}$]**-LIO**
hexagonal, $P\bar{6}$, a = 12.870Å, c = 16.096Å [(2)]

Framework density: 17.6 T/1000$Å^3$

Channels: apertures formed by 6-rings only



framework viewed normal to [001] (top left: projection down [001])

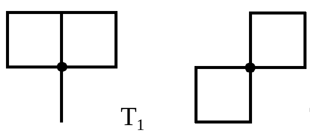
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 12.6Å, c = 10.3Å

Coordination sequences and vertex symbols:

T_1 (12, m)	4	10	20	34	52	74	102	136	172	210	4·6·4·6·6·6
T_2 (12, 2)	4	10	20	34	54	78	104	134	168	210	4·4·6·6·6·6

Secondary building units: 6-2 or 6

Loop configuration of T-Atoms:



Framework description: ABAC sequence of 6-rings

Isotypic framework structures:

*Losod[1,2]
[Al-Ge-O**]-LOS**[3]
|Li-**|[**Be-P-O**]-LOS**[4]
Bystrite[5]

References:

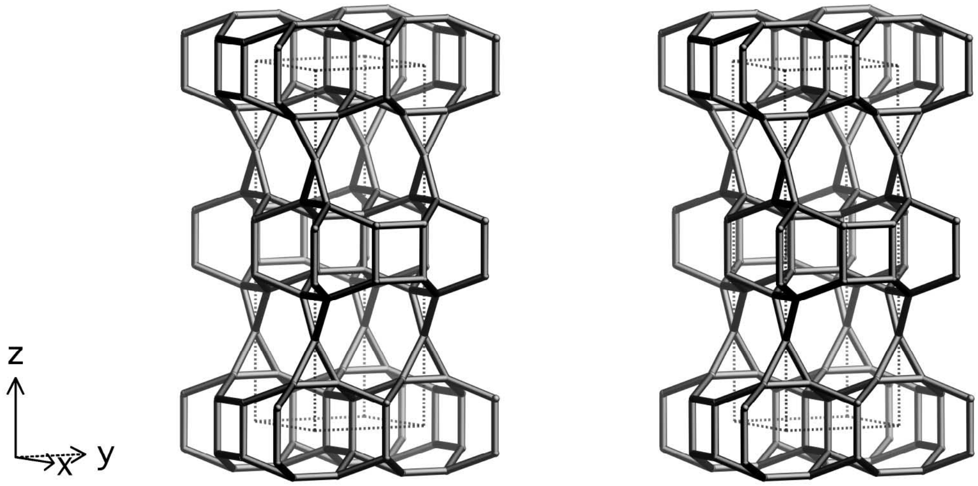
(1) Sieber, W. and Meier, W.M. *Helv. Chim. Acta*, **57**, 1533-1549 (1974)
(2) Schicker, P. *Ph.D. Thesis, ETH, Zürich, Switzerland*, (1988)
(3) Sokolov, Yu.A., Maksimov, B.A., Ilyukhin, V.V. and Belov, N.V. *Sov. Phys. Dokl.*, **23**, 789-791 (1978)
(4) Harrison, W.T.A., Gier, T.E. and Stucky, G.D. *Zeolites*, **13**, 242-248 (1993)
(5) Pobedimskaya, E.A., Terent'eva, L.F., Sapozhnikov, A.N., Kashaev, A.A. and Dorokhova, G.I. *Sov. Phys. Dokl.*, **36**, 553-555 (1991)

Crystal chemical data: $|Na^{+}_{12}\ (H_2O)_{18}|\ [Al_{12}Si_{12}\ O_{48}]$**-LOS**
hexagonal, $P6_3mc$, a = 12.906Å, c = 10.541Å [(2)]

Framework density: 15.8 T/1000$Å^3$

Channels: apertures formed by 6-rings only

LOV Framework Type $P4_2/mmc$



framework viewed normal to [001]

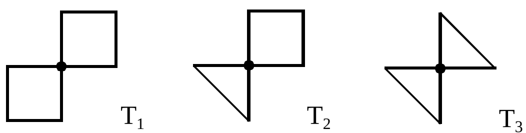
Idealized cell constants: tetragonal, $P4_2/mmc$, a = 7.2Å, c = 20.9Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	10	21	37	58	87	111	138	187	232	$4 \cdot 4 \cdot 6_2 \cdot 8 \cdot 6_2 \cdot 8$
T_2 (8, m)	4	9	19	39	55	79	113	149	177	229	$3 \cdot 4 \cdot 8_3 \cdot 9_4 \cdot 8_3 \cdot 9_4$
T_3 (2, $\bar{4}$2m)	4	8	20	40	54	76	116	144	200	210	$3 \cdot 3 \cdot 9_4 \cdot 9_4 \cdot 9_4 \cdot 9_4$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:
*Lovdarite[1,2]
Synthetic lovdarite[3]

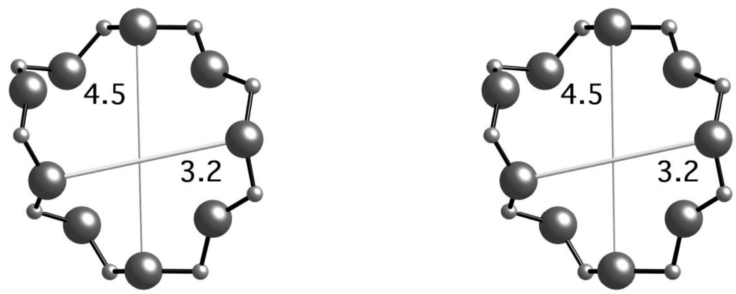
References:

(1) Merlino, S. *Acta Crystallogr. (Suppl.)*, **A37**, C189 (1981)
(2) Merlino, S. *Eur. J. Mineral.*, **2**, 809-817 (1990)
(3) Ueda, S., Koizumi, M., Baerlocher, Ch., McCusker, L.B. and Meier, W.M. *Preprints of Poster Papers, 7th Int. Zeolite Conf.*, pp. 23-24 (1986), Jap. Assoc. Zeolite, Tokyo

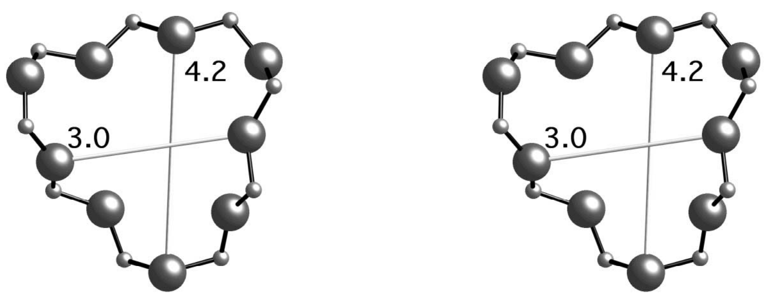
Crystal chemical data: |$K^{+}_{4}Na^{+}_{12}$ $(H_2O)_{18}$| **[**Be_8Si_{28} O_{72}**]-LOV**
orthorhombic, Pma2, a = 39.576Å, b = 6.931Å, c = 7.153Å [(2)]
(Relationship to unit cell of Framework Type: a' = 2c, b' = c' = a)

Framework density: 18.3 T/1000Å^3

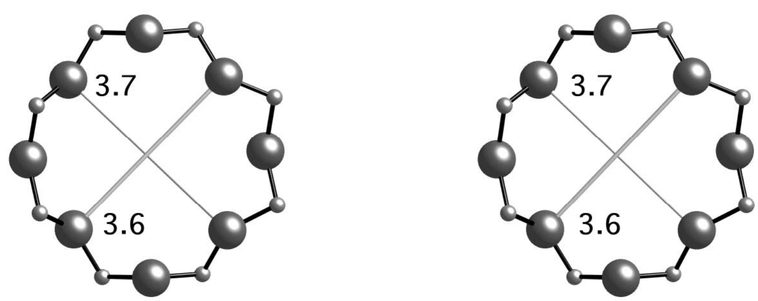
Channels: [010] **9** 3.2 x 4.5* ↔ [001] **9** 3.0 x 4.2*↔ [100] **8** 3.6 x 3.7*



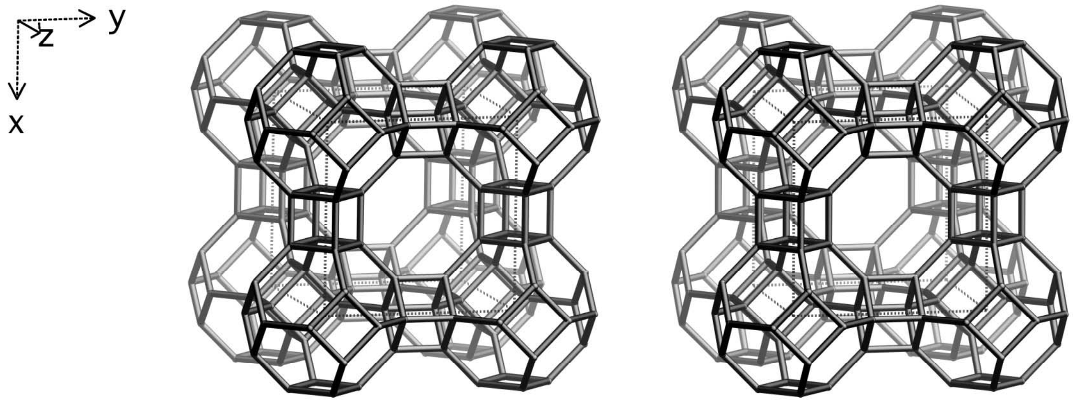
9-ring viewed along [010]



9-ring viewed along [001]



8-ring viewed along [100]



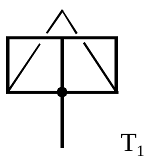
framework viewed along [001]

Idealized cell constants: cubic, $Pm\bar{3}m$, a = 11.9Å

Coordination sequences and vertex symbols: T_1 (24, m) 4 9 17 28 42 60 81 105 132 162 4·6·4·6·4·8

Secondary building units: 8 or 4-4 or 6-2 or 4-2 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:

*Linde Type A[1,2]
[Al-Ge-O**]-LTA**[3]
[Ga-P-O**]-LTA**[4]
Alpha[5]
LZ-215[6]
N-A[7]
SAPO-42[8]
ZK-21[9]
ZK-22[9]
ZK-4[10]

References:

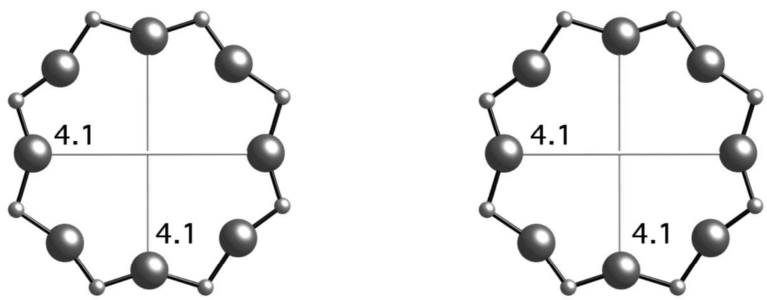
(1) Reed, T.B. and Breck, D.W. *J. Am. Chem. Soc.*, **78**, 5972-5977 (1956)
(2) Gramlich, V. and Meier, W.M. *Z. Kristallogr.*, **133**, 134-149 (1971)
(3) Barrer, R.M., Baynham, J.W., Bultitude, F.W. and Meier, W.M. *J. Chem. Soc.*, 195-208 (1959)
(4) Simmen, A., Patarin, J. and Baerlocher, Ch. In *Proc. 9th Int. Zeolite Conf.*, (eds. R. von Ballmoos, J.B. Higgins and M.M.J. Treacy), pp. 433-440 (1993), Butterworth-Heinemann, Boston
(5) Wadlinger, R.L., Rosinski, E.J. and Plank, C.J. *U.S. Patent 3,375,205* (1968)
(6) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(7) Barrer, R.M. and Denny, P.J. *J. Chem. Soc.*, 971-982 (1961)
(8) Lok, B.M., Messina, C.A., Patton, R.L., Gajek, R.T., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **106**, 6092-6093 (1984)
(9) Kuehl, G.H. *Inorg. Chem.*, **10**, 2488-2495 (1971)
(10) Kerr, G.T. *Inorg. Chem.*, **5**, 1537-1539 (1966)

Linde Type A — Type Material — LTA

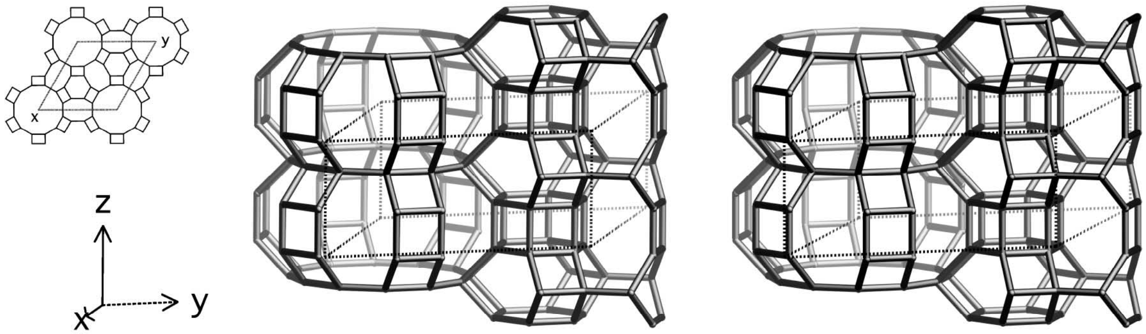
Crystal chemical data: $|Na^{+}_{12}\ (H_2O)_{27}|_8\ \mathbf{[}Al_{12}Si_{12}\ O_{48}\mathbf{]_8}$ **-LTA**
cubic, $Fm\bar{3}c$, a = 24.61Å [(2)]
(Relationship to unit cell of Framework Type: a' = b' = c' = 2a)

Framework density: 12.9 T/1000Å^3

Channels: <100> **8** 4.1 x 4.1***



8-ring viewed along <100>



framework viewed normal to [001]

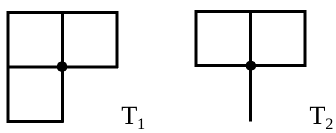
Idealized cell constants: hexagonal, P6/mmm, a = 18.1Å, c = 7.6Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	29	46	69	98	131	162	187	4·4·4·6·6·8
T_2 (12, m)	4	10	21	35	49	66	89	117	150	190	$4·8_3·4·8_3·6·12$

Secondary building units: 8 or 6

Loop configuration of T-Atoms:



Isotypic framework structures:

*Linde Type L[1]
(K,Ba)-G,L[2]
Gallosilicate L[3,4]
LZ-212[5]
Perlialite[6,7]

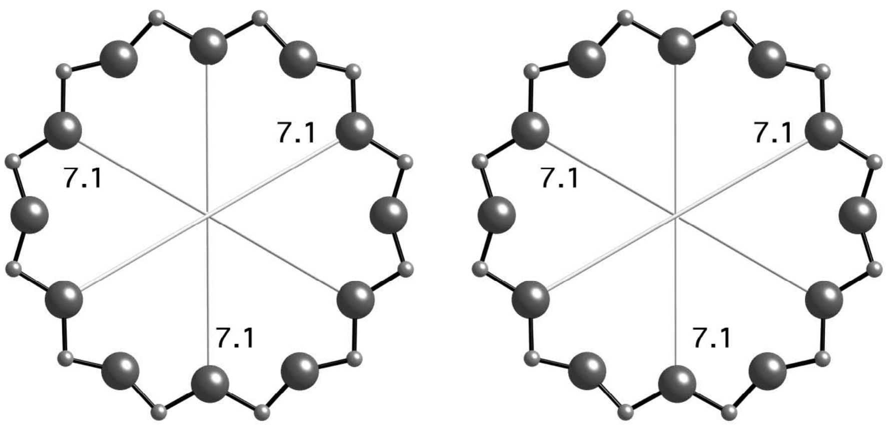
References:

(1) Barrer, R.M. and Villiger, H. *Z. Kristallogr.*, **128**, 352-370 (1969)
(2) Baerlocher, Ch. and Barrer, R.M. *Z. Kristallogr.*, **136**, 245-254 (1972)
(3) Wright, P.A., Thomas, J.M., Cheetham, A.K. and Nowak, A.K. *Nature*, **318**, 611-614 (1985)
(4) Newsam, J.M. *Mater. Res. Bull.*, **21**, 661-672 (1986)
(5) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(6) Menshikov, Y.P. *Zap. Vses. Mineral. O-va*, **113**, 607-612 (1984)
(7) Artioli, G. and Kvick, Å. *Eur. J. Mineral.*, **2**, 749-759 (1990)

Crystal chemical data: |$K^+_6Na^+_3$ $(H_2O)_{21}$| **[**Al_9Si_{27} O_{72}**]-LTL**
hexagonal, P6/mmm, a = 18.40Å, c = 7.52Å [(2)]

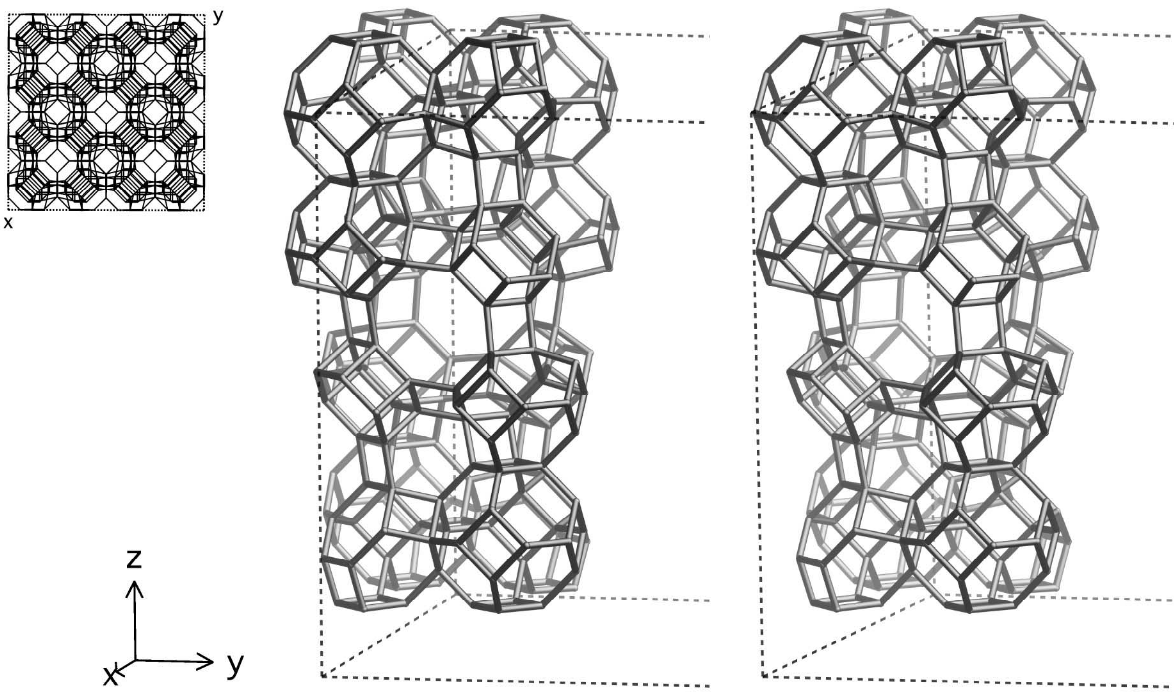
Framework density: 16.3 T/1000Å^3

Channels: [001] **12** 7.1 x 7.1*



12-ring viewed along [001]

LTN Framework Type $Fd\bar{3}m$



framework viewed normal to [001] (top left: projection down [001])

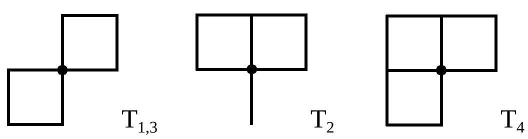
Idealized cell constants: cubic, $Fd\bar{3}m$, a = 35.6Å

Coordination sequences and vertex symbols:

T_1 (192, 1)	4	10	20	34	53	76	102	132	166	205		4·4·6·6·6·6
T_2 (192, 1)	4	10	20	34	51	71	96	126	162	202		4·6·4·6·6·6
T_3 (192, 1)	4	10	20	33	50	71	97	129	163	200		4·4·6·6·6·8
T_4 (192, 1)	4	9	17	30	49	72	97	125	158	197		4·4·4·8·6·6

Secondary building units: 6-2 or 6 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Linde Type N[1]
NaZ-21[2]

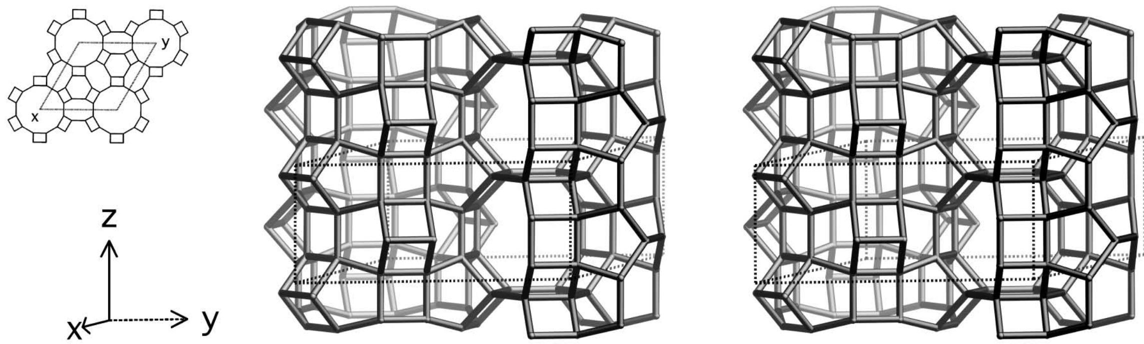
References:

(1) Fälth, L. and Andersson, S. *Z. Kristallogr.*, **160**, 313-316 (1982)
(2) Shepelev, Yu.F., Smolin, Yu.I., Butikova, I.K. and Tarasov, V.I. *Dokl. Akad. Nauk SSSR*, **272**, 1133-1137 (1983)

Crystal chemical data: |Na^+_{384} $(H_2O)_{518}$| [$Al_{384}Si_{384}$ O_{1536}]-**LTN**
cubic, $Fd\overline{3}$, a = 36.93Å [(1)]

Framework density: 15.2 T/1000Å^3

Channels: apertures formed by 6-rings only



framework viewed normal to [001] (top left: projection down [001])

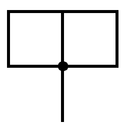
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 18.1Å, c = 7.6Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	10	20	35	54	78	104	134	171	210	4·5·4·5·8·12
T_2 (12, m)	4	10	21	36	53	74	104	138	174	212	$4 \cdot 8_2 \cdot 4 \cdot 8_2 \cdot 5 \cdot 6$

Secondary building units: 5-1 or 4-2 or 4

Loop configuration of T-Atoms:



$T_{1,2}$

Isotypic framework structures:

*Mazzite[1,2]
[Ga-Si-O**]-MAZ**[3]
LZ-202[4]
Omega[5]
ZSM-4[6]

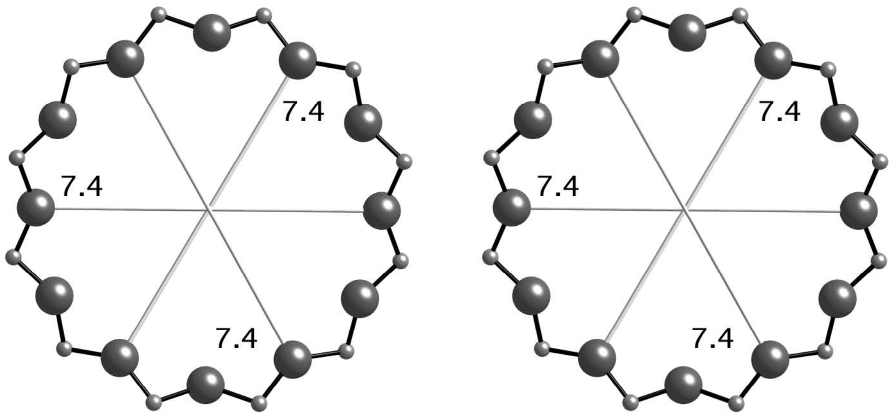
References:

(1) Galli, E. *Cryst. Struct. Comm.*, **3**, 339-344 (1974)
(2) Galli, E. *Rend. Soc. Ital. Mineral. Petrol.*, **31**, 599-612 (1975)
(3) Newsam, J.M., Jarman, R.H. and Jacobson, A.J. *Mater. Res. Bull.*, **20**, 125-136 (1985)
(4) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(5) Galli, E. *Cryst. Struct. Comm.*, **3**, 339-344 (1974)
(6) Rubin, M.K., Plank, C.J. and Rosinski, E.J. *U.S. Patent 4,021,447* (1977)

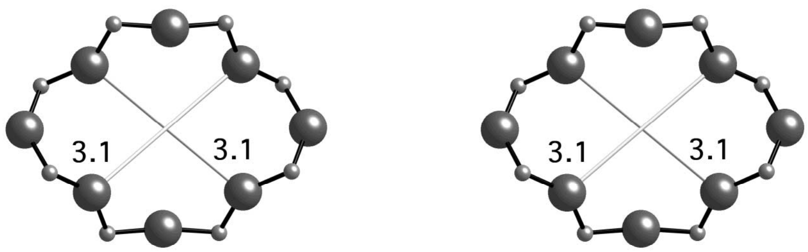
Crystal chemical data: **|**$(Na^{+}{}_{2},K^{+}{}_{2},Ca^{2+},Mg^{2+})_{5}\ (H_{2}O)_{28}$**|** **[**$Al_{10}Si_{26}\ O_{72}$**]-MAZ**
hexagonal, $P6_{3}/mmc$, a = 18.392Å, c = 7.646Å (2)

Framework density: 16.1 T/1000Å^{3}

Channels: [001] **12** 7.4 x 7.4* | [001] **8** 3.1 x 3.1***

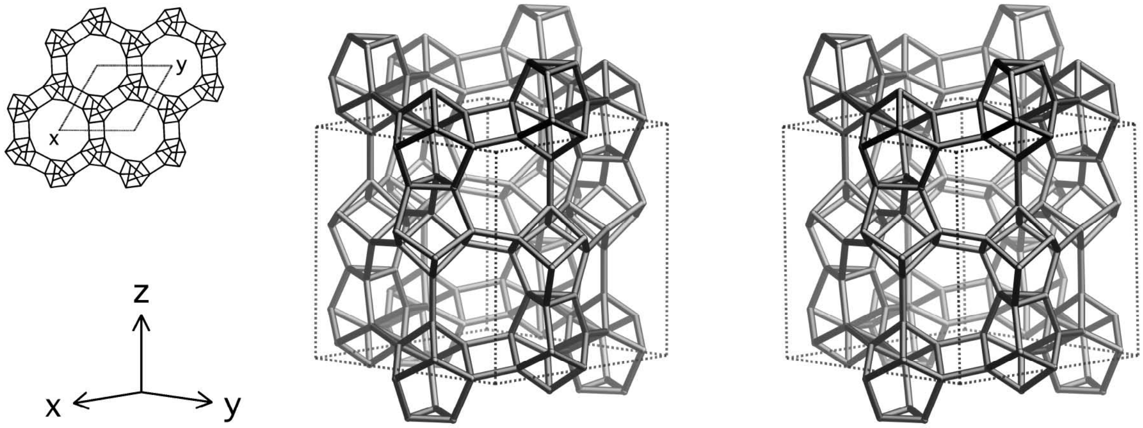


12-ring viewed along [001]



limiting 8-ring along [001]

MEI Framework Type $P6_3/m$



framework viewed normal to [001] (top left: projection down [001])

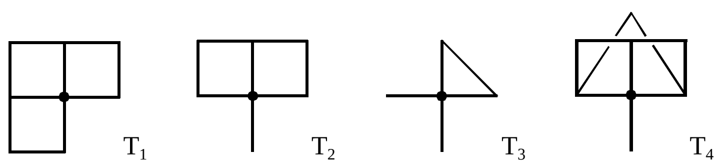
Idealized cell constants: hexagonal, $P6_3/m$, a = 13.1Å, c = 15.6Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	9	18	30	46	63	94	125	152	183	4·4·4·12·5·7
T_2 (12, 1)	4	10	17	30	46	67	91	123	153	190	4·5·4·7·5·12
T_3 (6, m)	4	10	16	26	46	66	94	114	158	194	3·7·5·5·5·5
T_4 (4, 3)	4	9	18	30	39	67	98	121	147	189	4·7·4·7·4·7

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *ZSM-18[1]

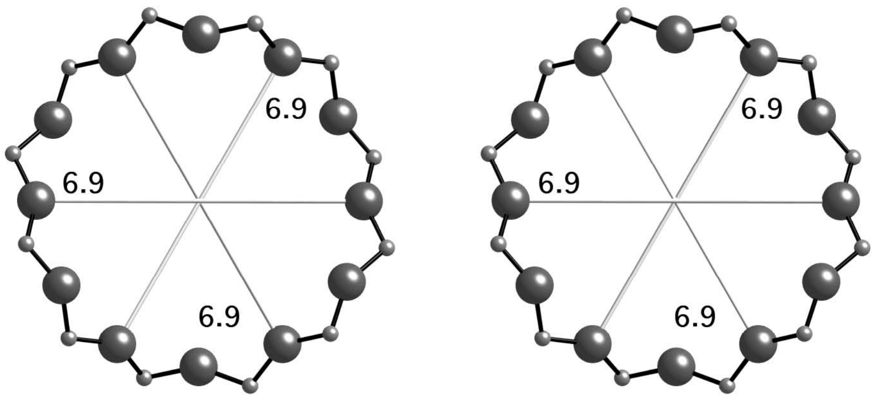
References:

(1) Lawton, S.L. and Rohrbaugh, W.J. *Science*, **247**, 1319-1321 (1990)

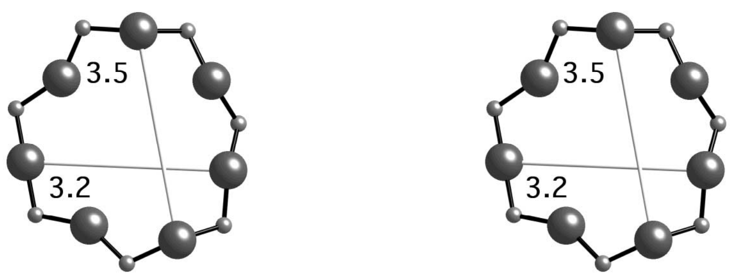
Crystal chemical data: |Na^+_n $(H_2O)_{28}$| [Al_nSi_{34-n} O_{68}]-**MEI**, n = 2.1 - 5.7
hexagonal, $P6_3/m$, a = 13.175Å, c = 15.848Å (1)

Framework density: 14.3 T/1000Å^3

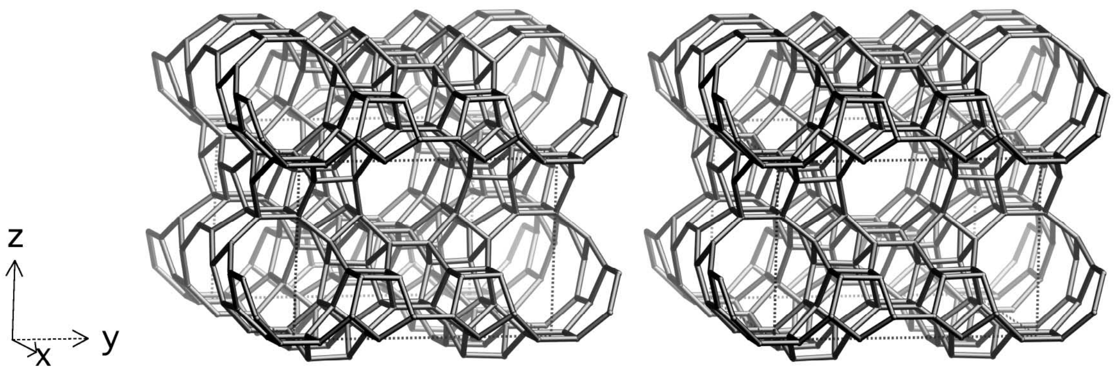
Channels: [001] **12** 6.9 x 6.9* ↔ ⊥ [001] **7** 3.2 x 3.5**



12-ring viewed along [001]



7-ring viewed normal to [001]



framework viewed along [100]

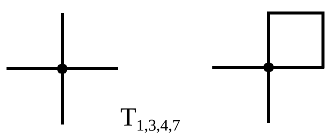
Idealized cell constants: tetragonal, $I\bar{4}m2$, a = 20.3Å, c = 13.5Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	12	21	36	63	88	121	153	192	249	5·5·5·5·5·6
T_2 (16, 1)	4	11	23	38	61	93	121	153	198	246	$4\cdot5\cdot5\cdot6_2\cdot5\cdot10_2$
T_3 (16, 1)	4	12	23	38	62	91	116	155	203	244	$5\cdot5\cdot5\cdot5_2\cdot5\cdot10_3$
T_4 (16, 1)	4	12	23	38	59	87	122	158	198	243	$5\cdot6_2\cdot5\cdot10_2\cdot5_2\cdot6$
T_5 (16, 1)	4	11	22	36	57	90	127	157	194	244	$4\cdot5\cdot5\cdot6\cdot5\cdot8_2$
T_6 (8, 2)	4	11	23	38	57	88	126	158	191	236	$4\cdot5_2\cdot6_2\cdot6_2\cdot10\cdot10$
T_7 (8, 2)	4	12	21	40	63	83	124	155	197	244	$5\cdot5\cdot5\cdot5\cdot5_2\cdot10_2$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures:

*ZSM-11[1-3]
Bor-D (**MFI**/**MEL** intergrowth)[4]
Boralite D[5]
SSZ-46[6,7]
Silicalite 2[8]
TS-2[9]

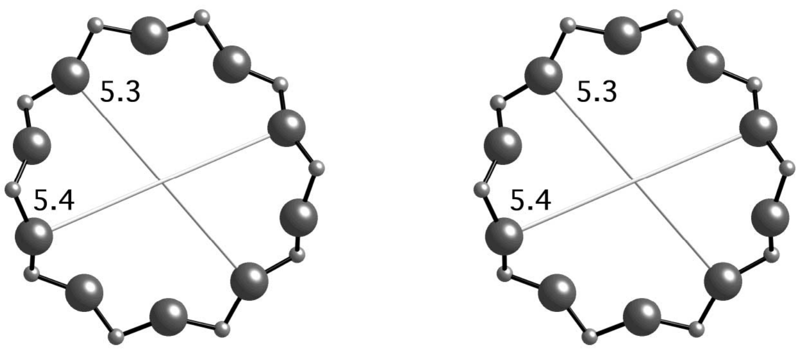
References:

(1) Kokotailo, G.T., Chu, P., Lawton, S.L. and Meier, W.M. *Nature*, **275**, 119-120 (1978)
(2) Fyfe, C.A., Gies, H., Kokotailo, G.T., Pasztor, C., Strobl, H. and Cox, D.E. *J. Am. Chem. Soc.*, **111**, 2470-2474 (1989)
(3) van Koningsveld, H., den Exter, M.J., Koegler, J.H., Laman, C.D., Njo, S.L. and Graafsma, H. In *Proc. 12th Int. Zeolite Conf.*, (eds. M.M.J. Treacy, B.K. Marcus, M.E. Bisher and J.B. Higgins), pp. 2419-2424 (1999), MRS, Warrendale, PA
(4) Perego, G. and Cesari, M. *J. Appl. Crystallogr.*, **17**, 403-410 (1984)
(5) Taramasso, M., Manara, G., Fattore, V. and Notari, B. *GB Patent 2,024,790*, (1980)
(6) Terasaki, O., Ohsuna, T., Sakuma, H., Watanabe, D., Nakagawa, Y. and Medrud, R.C. *Chem. Mater.*, **8**, 463-468 (1996)
(7) Nakagawa, Y. and Dartt, C. *U.S. Patent 5,968,474* (1999)

Crystal chemical data: |Na^{+}_{n} $(H_2O)_{16}$| **[**Al_nSi_{96-n} O_{192}**]-MEL**, n < 16
tetragonal, $I\bar{4}m2$, a = 20.12Å, c = 13.44Å (1)

Framework density: 17.6 T/1000$Å^3$

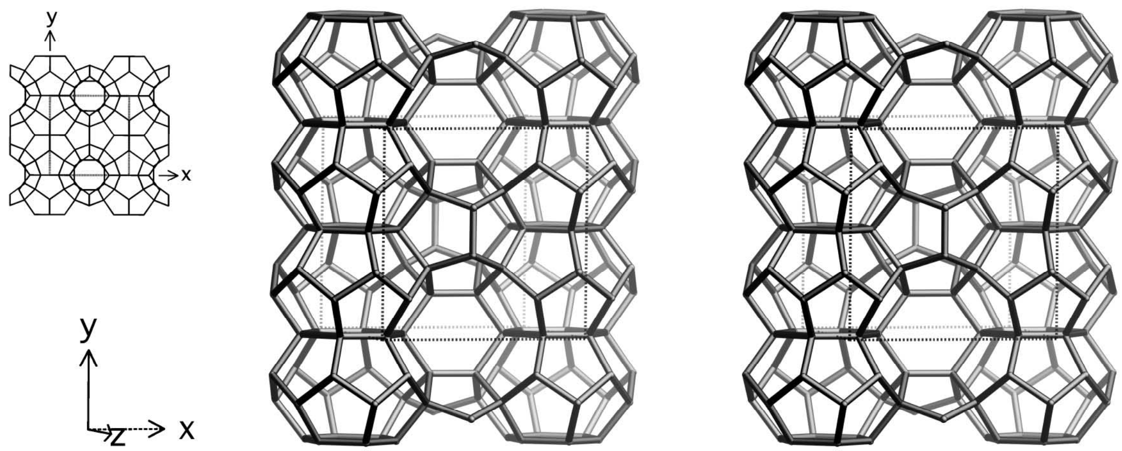
Channels: <100> **10** 5.3 x 5.4***



10-ring viewed along <100>

References (cont.):

(8) Bibby, D.M., Milestone, N.B. and Aldridge, L.P. *Nature*, **280**, 664-665 (1979)
(9) Reddy, J.S. and Kumar, R. *Zeolites*, **12**, 95-100 (1992)



framework viewed along [001] (top left: projection down [001])

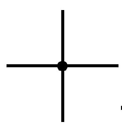
Idealized cell constants: cubic, Pm$\bar{3}$n, a = 13.7Å

Coordination sequences and vertex symbols:

T_1 (24, m)	4	12	25	42	69	100	129	176	229	277	5·5·5·5·5·6
T_2 (16, 3)	4	12	24	42	67	95	133	177	219	277	5·5·5·5·5·5
T_3 (6, $\bar{4}$2m)	4	12	26	44	64	98	144	172	222	272	5·5·5·5·6·6

Secondary building units: combinations only

Loop configuration of T-Atoms:



$T_{1\text{-}3}$

Isotypic framework structures: *Melanophlogite[1]
Synthetic melanophlogite[2]

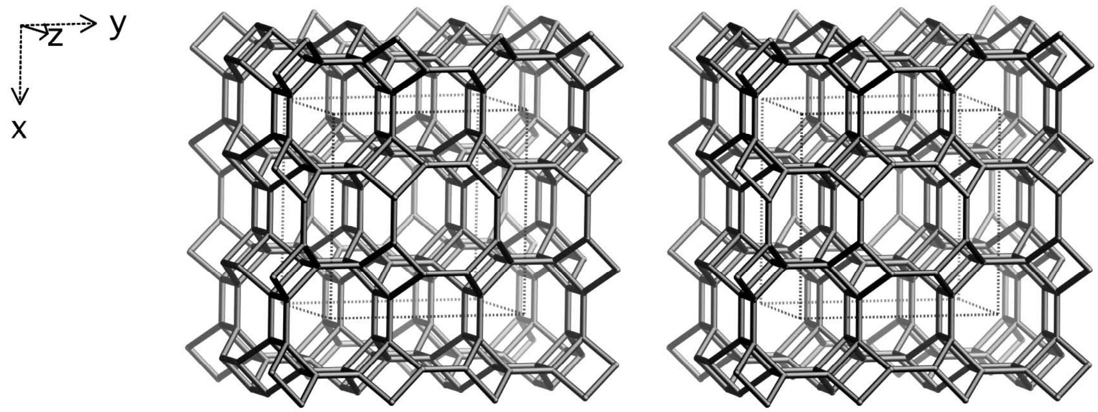
References:
(1) Gies, H. *Z. Kristallogr.*, **164**, 247-257 (1983)
(2) Gies, H., Gerke, H. and Liebau, F. *N. Jb. Miner. Mh.*, 119-124 (1982)

Crystal chemical data: |$(CH_4,N_2,CO_2)_x$| [Si_{46} O_{92}]-**MEP**
cubic, $Pm\bar{3}n$, a = 13.436Å [(1)]
(Data refer to structure at 200°; tetragonal at 25°C)

Framework density: 19 T/1000Å^3

Channels: apertures formed by 6-rings only

MER Framework Type I4/mmm



framework viewed along [001]

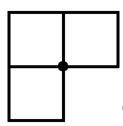
Idealized cell constants: tetragonal, I4/mmm, a = 14.0Å, c = 10.0Å

Coordination sequences and vertex symbols:

T_1 (32, 1)	4	9	18	32	49	69	93	121	153	189	$4 \cdot 4 \cdot 4 \cdot 8_2 \cdot 8 \cdot 8$

Secondary building units: 8-8 or 8 or 4

Loop configuration of T-Atoms:



T_1

Isotypic framework structures:

*Merlinoite[1,2]
[Al-Co-P-O**]-MER**[3]
|Ba-|**[**Al-Si-O**]-MER**[4]
|Ba-Cl-|**[**Al-Si-O**]-MER**[5]
|NH_4-|**[**Be-P-O**]-MER**[6]
K-M[4,7]
Linde W[4,8]
Synthetic merlinoite[9]
Zeolite W[10]

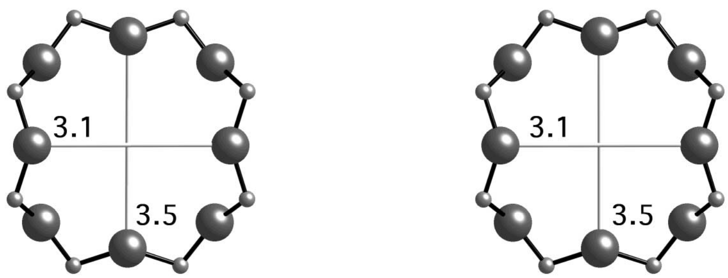
References:

(1) Passaglia, E., Pongiluppi, D. and Rinaldi, R. *N. Jb. Miner. Mh.*, 355-364 (1977)
(2) Galli, E., Gottardi, G. and Pongiluppi, D. *N. Jb. Miner. Mh.*, 1-9 (1979)
(3) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(4) Gottardi, G. and Galli, E. *Natural Zeolites*, p. 157 (1985), Springer-Verlag, Berlin
(5) Solov'eva, L.P., Borisov, S.V. and Bakakin, V.V. *Sov. Phys. Crystallogr.*, **16**, 1035-1038 (1972)
(6) Bu, X., Gier, T.E. and Stucky, G.D. *Microporous and Mesoporous Materials*, **26**, 61-66 (1998)
(7) Barrer, R.M. and Baynham, J.W. *J. Chem. Soc.*, 2882-2891 (1956)
(8) Sherman, J.D. *ACS Sym. Ser.*, **40**, 30-42 (1977)
(9) Barrett, P.A., Valencia, S. and Camblor, M.A. *J. Mater. Chem.*, **8**, 2263-2268 (1998)
(10) Bieniok, A., Bornholdt, K., Brendel, U. and Baur, W.H. *J. Mater. Chem.*, **6**, 271-275 (1996)

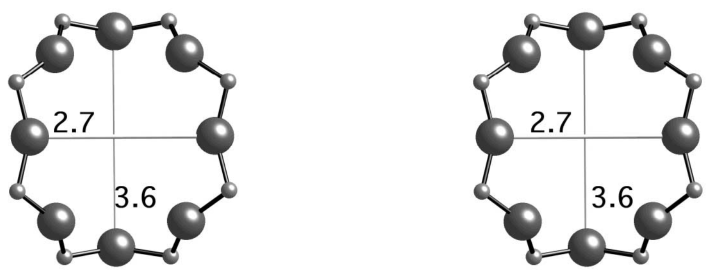
Crystal chemical data: **|**$K^{+}_{5}Ca^{2+}_{2}$ $(H_2O)_{24}$**|** **[**Al_9Si_{23} O_{64}**]-MER**
orthorhombic, Immm, a = 14.116Å, b = 14.229Å, c = 9.946Å [2]
(Relationship to unit cell of Framework Type: a' = b' = a, c' = c)

Framework density: 16 T/1000Å^3

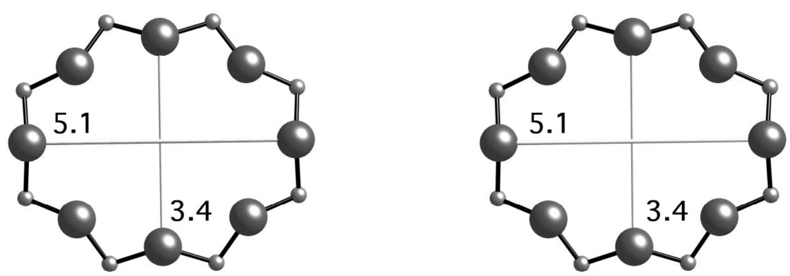
Channels: [100] **8** 3.1 x 3.5* ↔ [010] **8** 2.7 x 3.6*
↔ [001] {**8** 3.4 x 5.1* + **8** 3.3 x 3.3*}



8-ring viewed along [100]

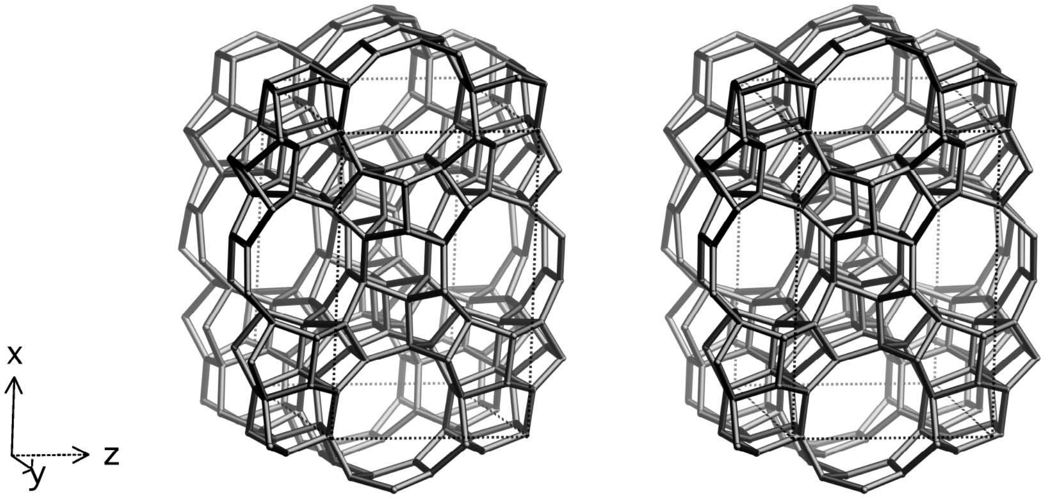


8-ring viewed along [010]



8-ring viewed along [001]

See Appendix A for 2nd 8-ring viewed along [001]



framework viewed along [010]

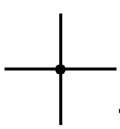
Idealized cell constants: orthorhombic, Pnma, a = 20.1Å, b = 19.7Å, c = 13.1Å

Coordination sequences and vertex symbols:

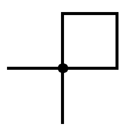
T_1 (8, 1)	4	12	22	41	61	88	125	159	198	250	$5·5·5·10_2·5_2·6$
T_2 (8, 1)	4	12	22	39	64	91	117	158	209	247	$5·5·5·5_2·5·10_3$
T_3 (8, 1)	4	12	23	37	62	91	120	157	206	250	$5·5·5·5_2·5·10_3$
T_4 (8, 1)	4	12	21	36	61	90	122	159	196	251	$5·5·5·5_2·5·6$
T_5 (8, 1)	4	12	24	38	63	93	123	157	206	247	$5·5·5·6_2·5·10_3$
T_6 (8, 1)	4	12	22	40	61	88	124	156	197	253	$5·5·5·5·5_2·10_3$
T_7 (8, 1)	4	12	24	38	56	90	132	164	193	241	$5·6_2·5_2·6_2·10·10$
T_8 (8, 1)	4	12	21	37	63	90	121	155	201	253	$5·5·5·5·5·6$
T_9 (8, 1)	4	11	23	39	62	93	119	153	204	254	$4·5·5·6_2·5·10_3$
T_{10} (8, 1)	4	11	22	36	61	93	120	154	200	255	$4·5·5·6_2·5·10_3$
T_{11} (8, 1)	4	12	22	38	59	92	125	159	202	250	$5·5·5·6·5·6_2$
T_{12} (8, 1)	4	12	23	38	59	89	126	161	196	246	$5·6_2·5·10_2·5_2·6_2$

Secondary building units: 5-1

Loop configuration of T-Atoms:



$T_{1-8,11,12}$



$T_{9,10}$

Isotypic framework structures: *ZSM-5[1-3]
(See Appendix A for additional structures and references)

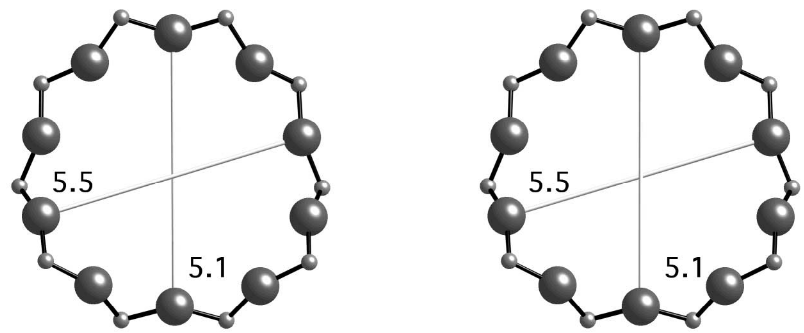
References:

(1) Kokotailo, G.T., Lawton, S.L., Olson, D.H. and Meier, W.M. *Nature*, **272**, 437-438 (1978)
(2) Olson, D.H., Kokotailo, G.T., Lawton, S.L. and Meier, W.M. *J. Phys. Chem.*, **85**, 2238-2243 (1981)
(3) van Koningsveld, H., van Bekkum, H. and Jansen, J.C. *Acta Crystallogr.*, **B43**, 127-132 (1987)

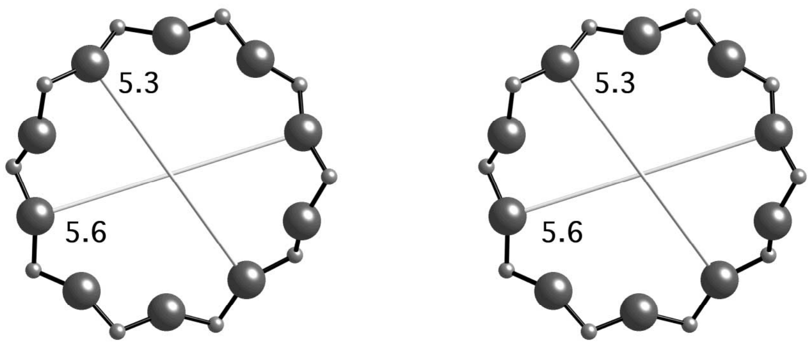
Crystal chemical data: |Na^{+}_{n} $(H_2O)_{16}$| **[**Al_nSi_{96-n} O_{192}**]-MFI**, n < 27
orthorhombic, Pnma, a = 20.07Å, b = 19.92Å, c = 13.42Å [(2)]

Framework density: 17.9 T/1000$Å^3$

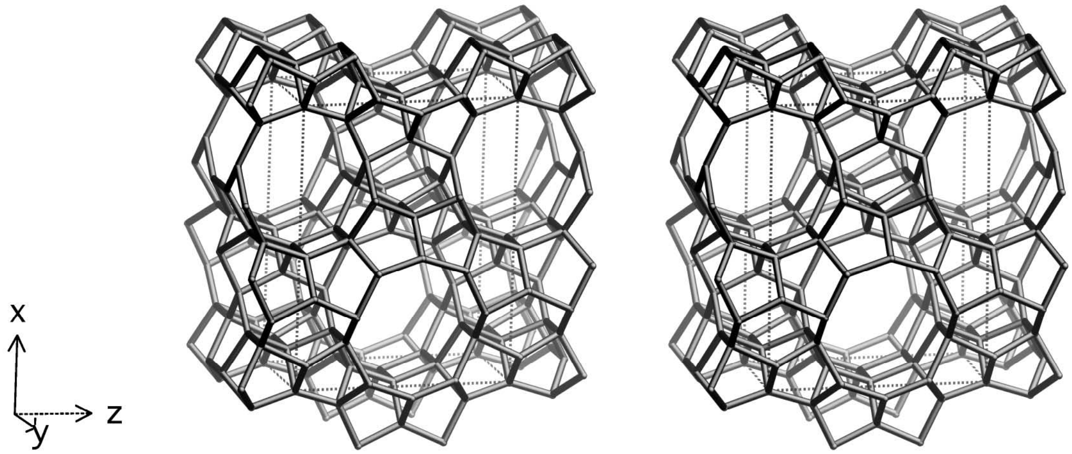
Channels: {[100] **10** 5.1 x 5.5 ↔ [010] **10** 5.3 x 5.6}***



10-ring viewed along [100]



10-ring viewed along [010]



framework viewed along [010]

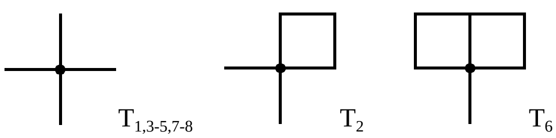
Idealized cell constants: orthorhombic, Imm2, a = 7.5Å, b = 14.4Å, c = 19.0Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	12	23	39	62	93	127	165	210	260	$5\cdot5\cdot5\cdot5\cdot5\cdot8_2$
T_2 (8, 1)	4	11	20	39	66	92	124	163	215	257	$4\cdot5_2\cdot5\cdot5\cdot8\cdot10$
T_3 (4, m)	4	12	24	42	64	90	131	168	206	259	$5\cdot5\cdot5\cdot5\cdot5\cdot10_2$
T_4 (4, m)	4	12	26	40	60	94	136	168	200	259	$5_2\cdot5_2\cdot6\cdot8\cdot6\cdot8$
T_5 (4, m)	4	12	19	35	64	96	123	155	207	272	$5\cdot5_2\cdot5\cdot5_2\cdot6\cdot*$
T_6 (4, m)	4	10	22	36	64	98	124	158	213	260	$4\cdot5\cdot4\cdot5\cdot8_2\cdot10$
T_7 (2, mm2)	4	12	22	40	62	92	138	160	196	262	$5\cdot5\cdot5\cdot5\cdot6_2\cdot*$
T_8 (2, mm2)	4	12	24	38	66	100	118	162	220	262	$5\cdot5\cdot5\cdot5\cdot5_2\cdot10_2$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures: *ZSM-57[(1)]

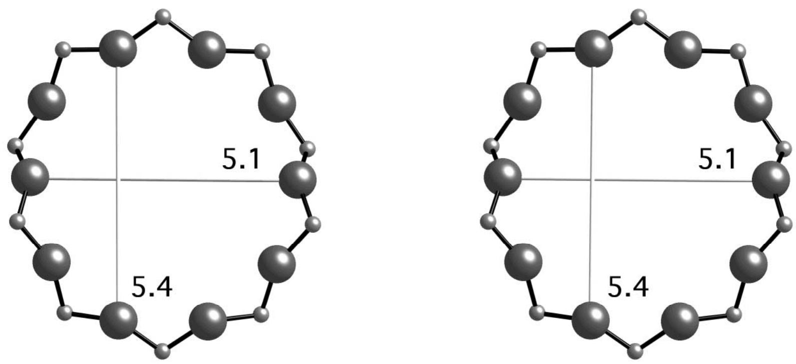
References:

(1) Schlenker, J.L., Higgins, J.B. and Valyocsik, E.W. *Zeolites*, **10**, 293-296 (1990)

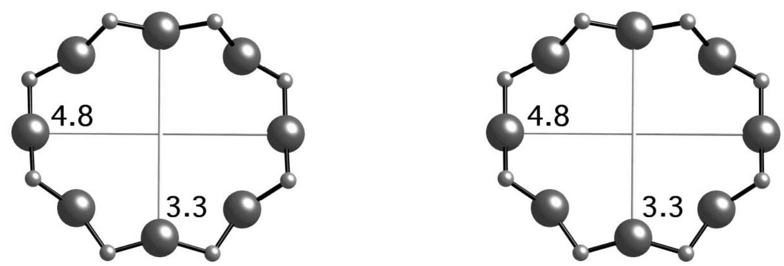
Crystal chemical data: |$H^+_{1.5}$| [$Al_{1.5}Si_{34.5}$ O_{72}]-**MFS**
orthorhombic, Imm2, a = 7.451Å, b = 14.171Å, c = 18.767Å (1)

Framework density: 18.2 T/1000Å^3

Channels: [100] **10** 5.1 x 5.4* ↔ [010] **8** 3.3 x 4.8*

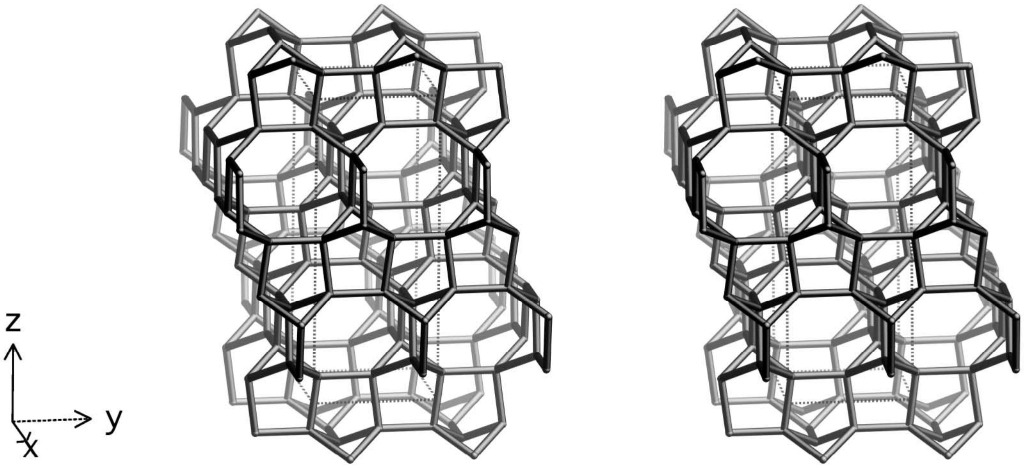


10-ring viewed along [100]



8-ring viewed along [010]

MON Framework Type $I4_1/amd$



framework viewed along [100]

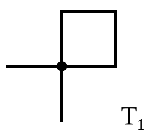
Idealized cell constants: tetragonal, $I4_1/amd$ (origin choice 2), a = 7.1Å, c = 17.8Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	11	23	44	67	95	134	168	215	271	$4 \cdot 5_2 \cdot 5 \cdot 8_2 \cdot 5 \cdot 8_2$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Montesommaite[1]

References:

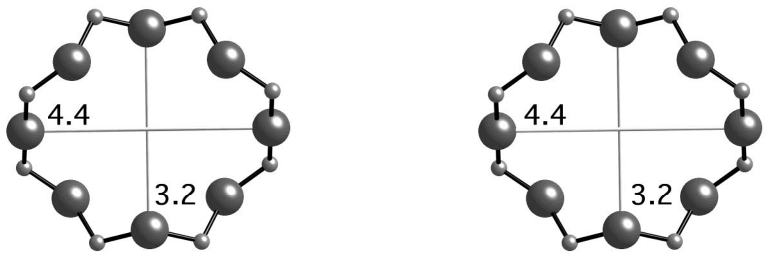
(1) Rouse, R.C., Dunn, P.J., Grice, J.D., Schlenker, J.L. and Higgins, J.B. *Am. Mineral.*, **75**, 1415-1420 (1990)

Montesommaite Type Material MON

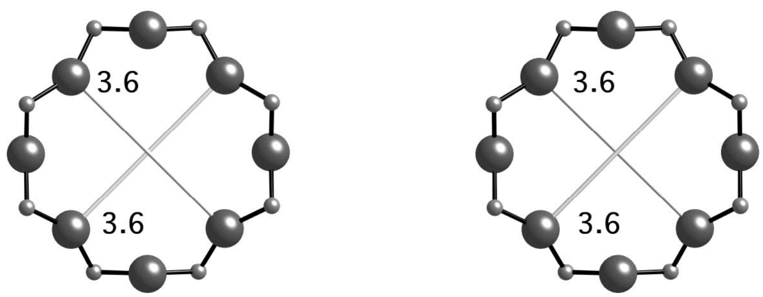
Crystal chemical data: **|**$(K^+,Na^+)_{4.5}$ $(H_2O)_5$**|** **[**$Al_{4.5}Si_{11.5}$ O_{32}**]-MON**
tetragonal, I4_1/amd, a = 7.141Å, c = 17.307Å [(1)]

Framework density: 18.1 T/1000$Å^3$

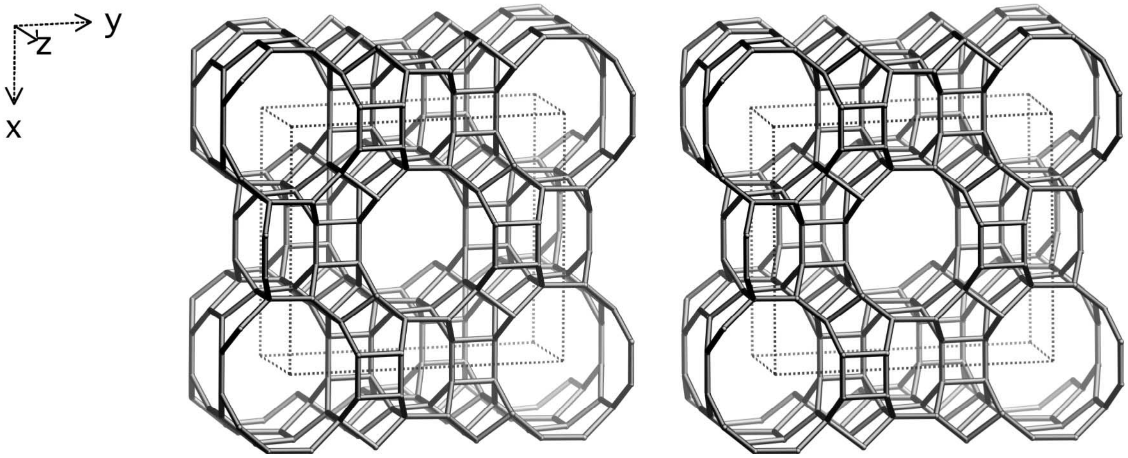
Channels: [100] **8** 3.2 x 4.4* ↔ [001] **8** 3.6 x 3.6*



8-ring viewed along [100]



8-ring viewed along [001]



framework viewed along [001]

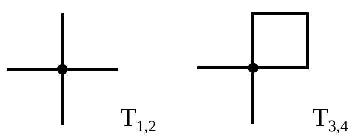
Idealized cell constants: orthorhombic, Cmcm, a = 18.3Å, b = 20.5Å, c = 7.5Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	12	22	38	60	88	115	155	204	242	$5\cdot5\cdot5\cdot5_2\cdot8\cdot12$
T_2 (16, 1)	4	12	20	37	64	87	114	154	198	241	$5\cdot5\cdot5\cdot5_2\cdot5\cdot8$
T_3 (8, m)	4	11	24	39	54	86	126	156	195	242	$4\cdot5_2\cdot5\cdot8_2\cdot5\cdot8_2$
T_4 (8, m)	4	11	24	39	60	92	122	148	195	250	$4\cdot5_2\cdot5\cdot8\cdot5\cdot8$

Secondary building units: 5-1

Loop configuration of T-Atoms:



Isotypic framework structures:
*Mordenite[1]
[Ga-Si-O**]-MOR**[2]
Ca-Q[3]
LZ-211[4]
Large port mordenite[5]
Maricopaite (interrupted framework)[6]
Na-D[7]

Alternate designation:
Ptilolite (discredited)
Arduinite (discredited)
Flokite (discredited)

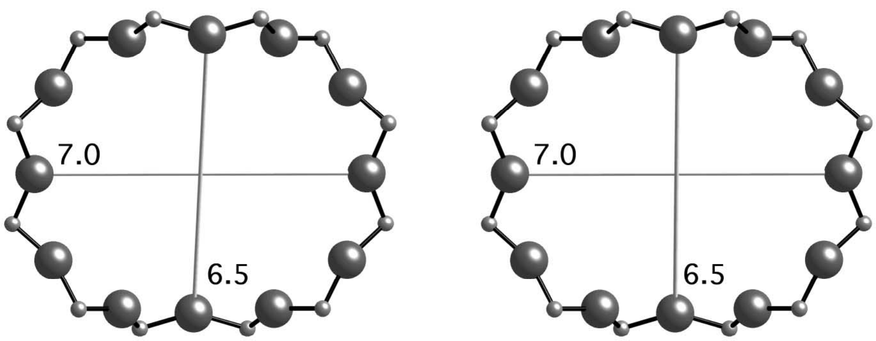
References:

(1) Meier, W.M. *Z. Kristallogr.*, **115**, 439-450 (1961)
(2) Eapen, M.J., Reddy, K.S.N., Joshi, P.N. and Shiralkar, V.P. *J. Incl. Phenom.*, **14**, 119-129 (1992)

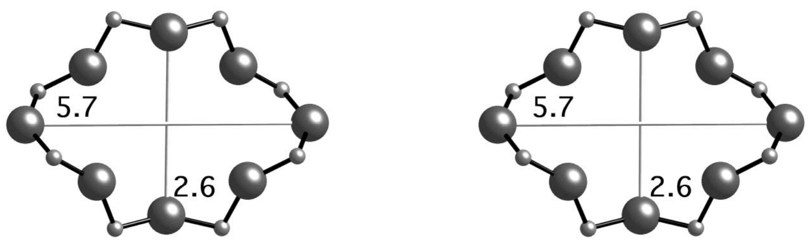
Crystal chemical data: **|**Na^{+}_{8} $(H_2O)_{24}$**|** **[**Al_8Si_{40} O_{96}**]-MOR**
orthorhombic, Cmcm, a = 18.1Å, b = 20.5Å, c = 7.5 Å [(1)]

Framework density: 17.2 T/1000Å^3

Channels: [001] **12** 6.5 x 7.0* ↔ {[010] **8** 3.4 x 4.8 ↔ [001] **8** 2.6 x 5.7}*



12-ring viewed along [001]



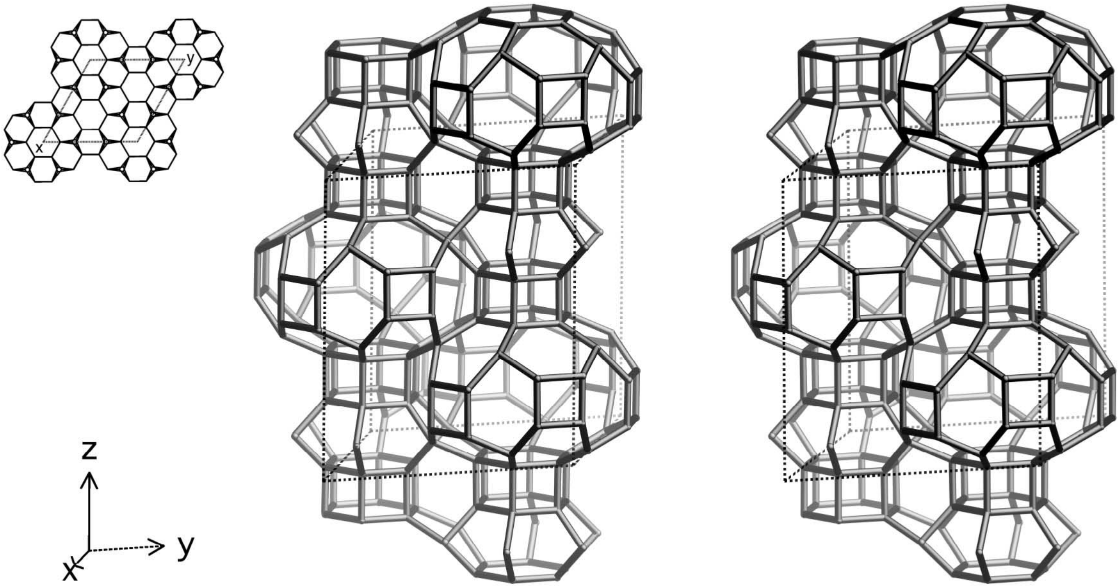
limiting 8 ring along [001]
between 12-ring channels

See Appendix A for 8-ring viewed along [010]

References (cont.):

(3) Koizumi, M. and Roy, R. *J. Geol.*, **68**, 41-53 (1960)
(4) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(5) Sand, L.B. In *Molecular Sieves*, (ed. R.M. Barrer), pp. 71-77 (1968), Soc. Chem. Indus., London
(6) Rouse, R.C. and Peacor, D.R. *Am. Mineral.*, **79**, 175-184 (1994)
(7) Barrer, R.M. and White, E.A.D. *J. Chem. Soc.*, 1561-1571 (1952)

MSO Framework Type $R\bar{3}m$



framework viewed normal to [001] (top left: projection down [001])

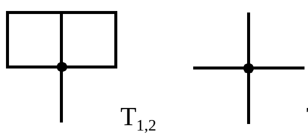
Idealized cell constants: trigonal, $R\bar{3}m$, a = 17.2Å, c = 19.8Å

Coordination sequences and vertex symbols:

T_1 (36, 1)	4	10	21	37	55	75	101	136	175	211	$4 \cdot 6 \cdot 4 \cdot 6_2 \cdot 6 \cdot 6$
T_2 (36, 1)	4	10	20	34	53	77	106	138	170	206	$4 \cdot 6_2 \cdot 4 \cdot 6_2 \cdot 6 \cdot 6$
T_3 (18, 2)	4	12	21	32	51	80	110	132	164	212	$6 \cdot 6 \cdot 6 \cdot 6_2 \cdot 6_2 \cdot 6_2$

Secondary building units: 2-6-2

Loop configuration of T-Atoms:



$T_{1,2}$ T_3

Isotypic framework structures: *MCM-61[1,2]

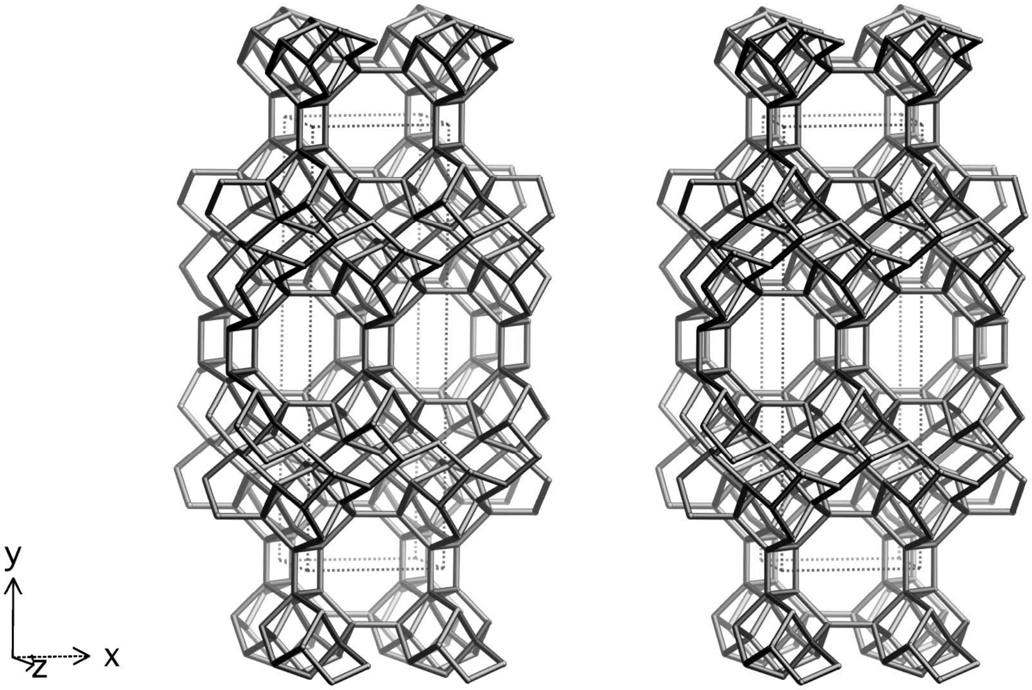
References:

(1) Valyosik, E.W. *U.S. Patent 5,670,131* (1997)
(2) Shantz, D.F., Burton, A. and Lobo, R.F. *Microporous and Mesoporous Materials,* **31**, 61-73 (1999)

Crystal chemical data: $|K^{+}_{2.1}\ C_{12}H_{24}O_6|$ **[**$Si_{27.9}Al_{2.1}\ O_{60}$**]-MSO**
$C_{12}H_{24}O_6$ = 18-crown-6
rhombohedral, $R\overline{3}m$, a = 11.841Å, α = 93.29° (2)
(hexagonal setting: a = 17.220Å, c = 19.296Å)

Framework density: 18.2 T/1000Å^3

Channels: apertures formed by 6-rings only



framework viewed along [001]

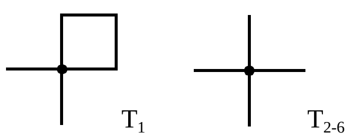
Idealized cell constants: monoclinic, C12/m1, a = 9.6Å, b = 30.4Å, c = 7.2Å, β = 90.5°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	24	45	77	109	137	174	224	280	$4\cdot5\cdot5\cdot6\cdot5\cdot8$
T_2 (8, 1)	4	12	24	42	70	95	136	184	227	277	$5\cdot5_2\cdot5\cdot6\cdot5\cdot8$
T_3 (8, 1)	4	12	27	47	69	99	142	184	227	281	$5\cdot6\cdot5\cdot7\cdot5\cdot8$
T_4 (8, 1)	4	12	26	45	64	96	134	186	230	290	$5\cdot6\cdot5\cdot6\cdot5\cdot6$
T_5 (8, 1)	4	12	24	42	64	93	133	179	234	290	$5\cdot6\cdot5\cdot6_2\cdot5\cdot7$
T_6 (4, 2)	4	12	21	44	74	106	138	172	226	284	$5\cdot5\cdot5\cdot5\cdot5_2\cdot6$

Secondary building units: 5-5=1

Loop configuration of T-Atoms:



Isotypic framework structures: *MCM-35[1]
UTM-1[2]

References:

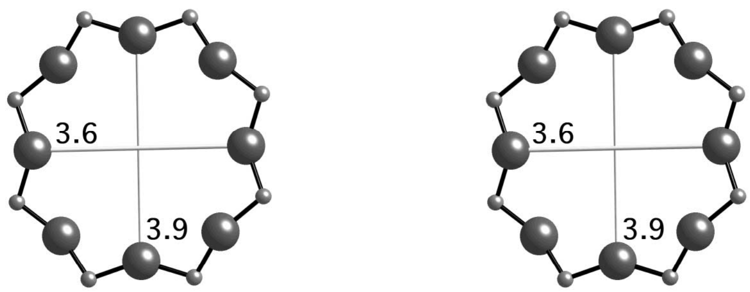
(1) Barrett, P.A., Díaz-Cabañas, M.J. and Camblor, M.A. *Chem. Mater.*, **11**, 2919-2927 (1999)

(2) Plévert, J., Yamamoto, K. Chiari, G. and Tatsumi, T. *J. Phys. Chem. B*, **103**, 8647-8649 (1999)

Crystal chemical data: **[**Si_{44} O_{88}**]-MTF**
monoclinic, C12/m1
a = 9.500 Å, b = 30.710Å, c = 7.313Å, β = 91.71° (1)

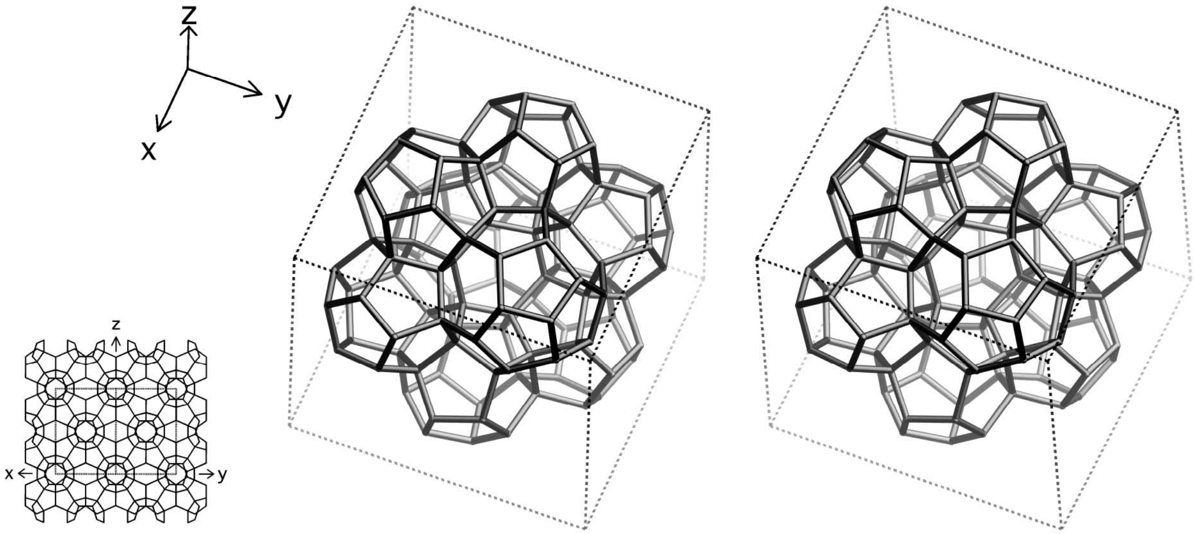
Framework density: 20.6 T/1000$Å^3$

Channels: [001] **8** 3.6 x 3.9*



8-ring viewed along [001]

MTN Framework Type $Fd\bar{3}m$



framework viewed along [111] (bottom left: projection down [110])

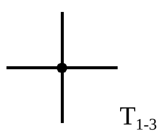
Idealized cell constants: cubic, $Fd\bar{3}m$ (origin choice 2), a = 19.9Å

Coordination sequences and vertex symbols:

T_1 (96, m)	4	12	25	43	68	95	133	177	223	274	5·5·5·5·5·6
T_2 (32, 3m)	4	12	24	39	66	103	130	168	216	274	5·5·5·5·5·5
T_3 (8, $\bar{4}$3m)	4	12	24	36	64	112	132	156	222	264	5·5·5·5·5·5

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:

*ZSM-39[1]
CF-4[2]
Dodecasil-3C[3]
Holdstite[4]

References:

(1) Schlenker, J.L., Dwyer, F.G., Jenkins, E.E., Rohrbaugh, W.J., Kokotailo G.T. and Meier, W.M. *Nature*, **294**, 340-342 (1981)

(2) Long, Y., He, H., Zheng, P., Guang, W. and Wang, B. *J. Incl. Phenom.*, **5**, 355-362 (1987)

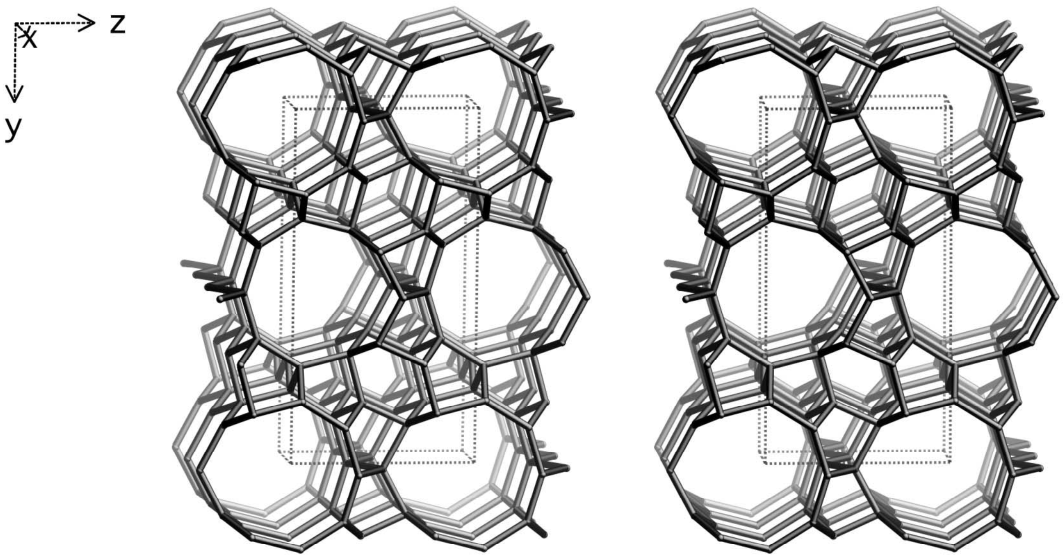
(3) Gies, H. *Z. Kristallogr.*, **167**, 73-82 (1984)

(4) Smith, J.V. and Blackwell, C.S. *Nature*, **303**, 223-225 (1983)

Crystal chemical data: $|(C_8H_{20}N^+)_n\ (OH)^-_n|\ [Si_{136}\ O_{272}]$-**MTN**
$C_8H_{20}N^+$ = tetraethylammonium
cubic, $Fd\bar{3}m$, a = 19.36Å [(1)]

Framework density: 18.7 T/1000Å^3

Channels: apertures formed by 6-rings only



framework viewed along [100]

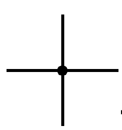
Idealized cell constants: orthorhombic, Pmmn (origin choice 1), a = 5.3Å, b = 22.0Å, c = 11.4Å

Coordination sequences and vertex symbols:

T_1 (4, m)	4	12	23	43	66	92	130	170	213	261	$5\cdot5\cdot5\cdot5\cdot6\cdot10_2$
T_2 (4, m)	4	12	24	40	64	96	136	167	207	258	$5_2\cdot6_2\cdot6\cdot6_2\cdot6\cdot6_2$
T_3 (4, m)	4	12	22	40	67	97	124	165	219	265	$5\cdot5\cdot5\cdot5\cdot6_2\cdot10_2$
T_4 (4, m)	4	12	22	40	65	98	132	159	206	278	$5\cdot5\cdot5\cdot5\cdot6_2\cdot*$
T_5 (4, m)	4	12	24	41	62	97	129	170	212	262	$5_2\cdot6_2\cdot6\cdot6_2\cdot6\cdot6_2$
T_6 (2, mm2)	4	12	22	42	66	94	126	164	220	270	$5\cdot5\cdot5\cdot5\cdot6_2\cdot10_2$
T_7 (2, mm2)	4	12	24	44	66	88	132	174	214	258	$5\cdot5\cdot5\cdot5\cdot10_2\cdot*$

Secondary building units: 5-1

Loop configuration of T-Atoms:



T_{1-7}

Isotypic framework structures:

*ZSM-23[1-3]
EU-13[4]
ISI-4[5]
KZ-1[6]

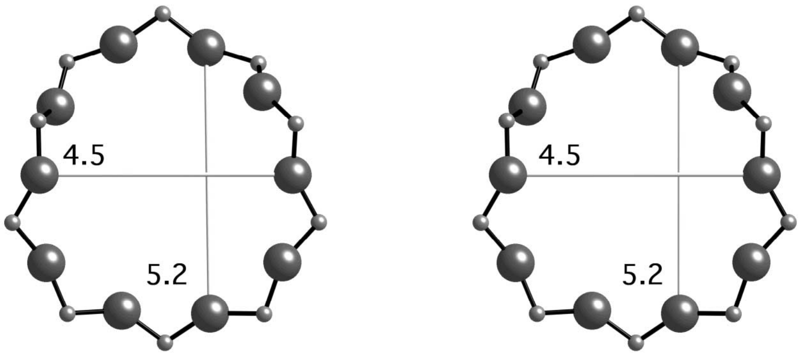
References:

(1) Schlenker, J.L., Higgins, J.B. and Cox, D.E. *private communication*
(2) Rohrman Jr., A.C., LaPierre, R.B., Schlenker, J.L., Wood, J.D., Valyocsik, E.W., Rubin, M.K., Higgins, J.B. and Rohrbaugh, W.J. *Zeolites*, **5**, 352-354 (1985)

Crystal chemical data: |Na^+_n $(H_2O)_4$| [Al_nSi_{24-n} O_{48}]-**MTT**, n < 2
orthorhombic, $Pmn2_1$, a = 21.5Å, b = 11.1Å, c = 5.0 Å [(1)]

Framework density: 20.1 T/1000$Å^3$

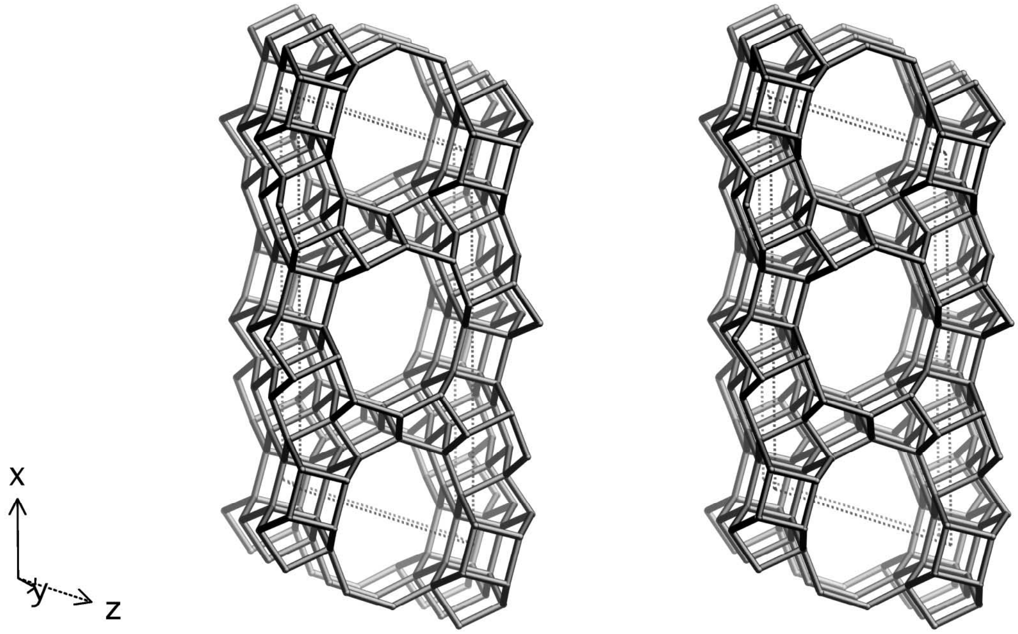
Channels: [001] **10** 4.5 x 5.2*



10-ring viewed along [001]

References (cont.):

(3) Marler, B., Deroche, C., Gies, H., Fyfe, C.A., Grondey, H., Kokotailo, G.T., Feng, Y., Ernst, S., Weitkamp, J. and Cox, D.E. *J. Appl. Crystallogr.*, **26**, 636-644 (1993)
(4) Araya, A. and Lowe, B.M. *U.S. Patent 4,581,211* (1986)
(5) Kakatsu, K. and Kawata, N. *Eur. Pat. Appl. EPA 102,497* (1984)
(6) Parker, L.M. and Bibby, D.M. *Zeolites*, **3**, 8-11 (1983)



framework viewed along [010]

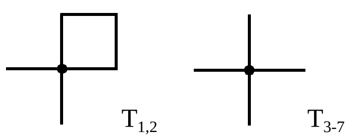
Idealized cell constants: monoclinic, C2/m, a = 25.6Å, b = 5.3Å, c = 12.1Å, β = 109.3°

Coordination sequences and vertex symbols:

T_1 (4, m)	4	11	22	38	60	88	113	147	190	243	$4\cdot6_2\cdot5\cdot6\cdot5\cdot6$
T_2 (4, m)	4	11	22	38	60	86	115	147	191	238	$4\cdot6_2\cdot5\cdot6\cdot5\cdot6$
T_3 (4, m)	4	12	21	37	62	84	119	147	188	239	$5\cdot6\cdot5\cdot6\cdot5_2\cdot6$
T_4 (4, m)	4	12	23	37	59	85	120	154	184	231	$5\cdot6\cdot5\cdot6\cdot6\cdot6_2$
T_5 (4, m)	4	12	21	37	58	87	119	154	182	227	$5\cdot6_2\cdot5\cdot6_2\cdot5_2\cdot6$
T_6 (4, m)	4	12	24	39	55	85	122	156	188	225	$5\cdot6_2\cdot5\cdot6_2\cdot6_2\cdot12_6$
T_7 (4, m)	4	12	23	38	59	83	115	155	192	233	$5\cdot5\cdot5\cdot5\cdot6\cdot12_6$

Secondary building units: 5-2

Loop configuration of T-Atoms:



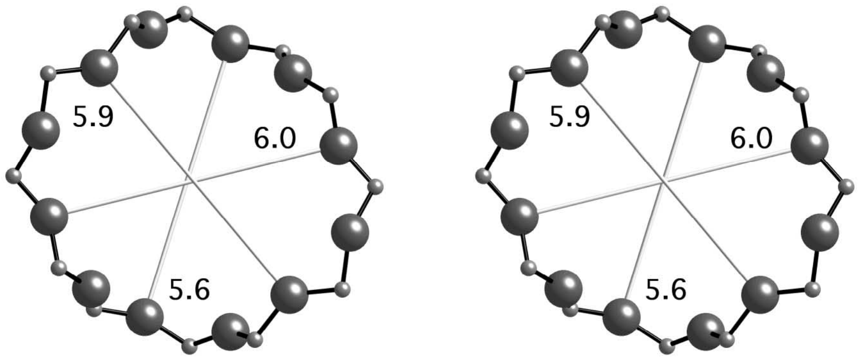
Isotypic framework structures:

*ZSM-12[1,2]
[Ga-Si-O**]-MTW**[3]
CZH-5[4]
NU-13[5]
TPZ-12[6]
Theta-3[7]
VS-12[8]

Crystal chemical data: |Na^+_n $(H_2O)_8$| [Al_nSi_{56-n} O_{112}]-**MTW**, n < 5
monoclinic, C12/c1
a = 24.863Å, b = 5.012Å, c = 24.328Å, β = 107.72° (2)

Framework density: 19.4 T/1000$Å^3$

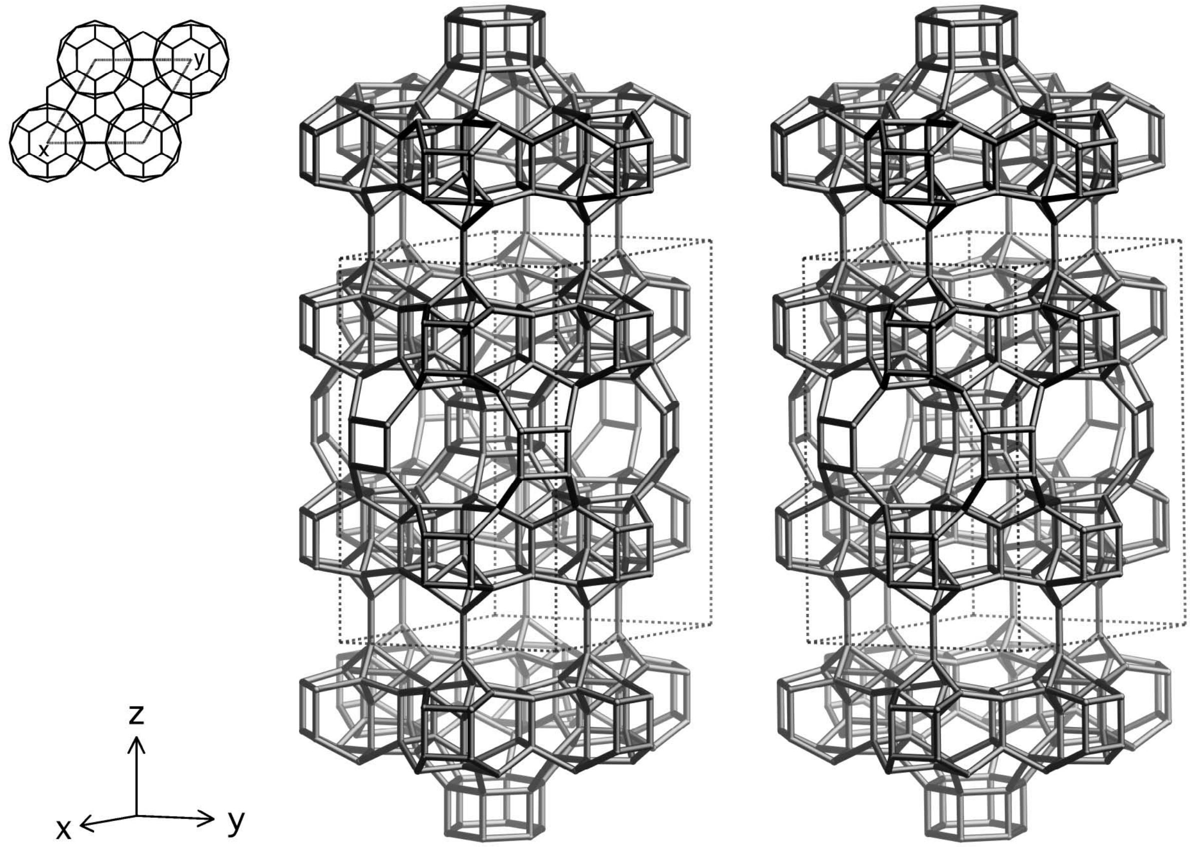
Channels: [010] **12** 5.6 x 6.0*



12-ring viewed along [010]

References:

(1) LaPierre, R.B., Rohrman Jr., A.C., Schlenker, J.L., Wood, J.D., Rubin, M.K. and Rohrbaugh, W.J. *Zeolites*, **5**, 346-348 (1985)
(2) Fyfe, C.A., Gies, H., Kokotailo, G.T., Marler, B. and Cox, D.E. *J. Phys. Chem.*, **94**, 3718-3721 (1990)
(3) Zhi, Y.X., Tuel, A., Bentaarit, Y. and Naccache, C. *Zeolites*, **12**, 138-141 (1992)
(4) Hickson, D.A. *UK Pat. Appl. GB 2079735A* (1981)
(5) Whittam, T.V. *Eur. Pat. Appl. EPA 0059059* (1982)
(6) Sumitani, K., Sakai, T., Yamasaki, Y. and Onodera, T. *U.S. Patent 4,557,919* (1985)
(7) Barlow, T.M. *E. Patent A-162,719* (1985)
(8) Reddy, K.M., Moudrakovski, I. and Sayari, A. *Chem. Commun.*, 1491-1492 (1994)



framework viewed normal to [001] (top left: projection down [001])

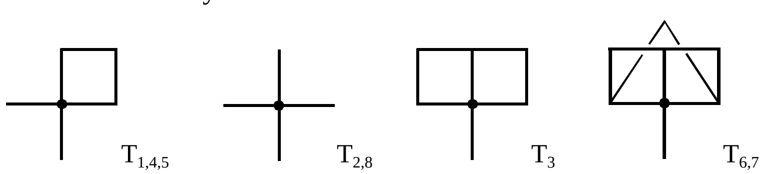
Idealized cell constants: hexagonal, P6/mmm, a = 14.4Å, c = 25.2Å

Coordination sequences and vertex symbols:

T_1 (12, .m.)	4	10	20	32	52	76	111	146	185	225	$4_2 \cdot 6 \cdot 5 \cdot 5 \cdot 5 \cdot 5$
T_2 (12, .m.)	4	12	22	35	51	81	109	137	175	218	$5 \cdot 5 \cdot 5 \cdot 5 \cdot 6 \cdot 10_2$
T_3 (12, .m.)	4	10	21	40	62	78	95	128	177	228	$4 \cdot 5 \cdot 4 \cdot 5 \cdot 6 \cdot 10_2$
T_4 (12, ..m)	4	11	18	32	52	78	107	147	187	215	$4 \cdot 10_2 \cdot 5_2 \cdot 6_2 \cdot 5_2 \cdot 6_2$
T_5 (12, ..m)	4	11	22	32	53	79	113	144	176	220	$4 \cdot 5 \cdot 5 \cdot 6_2 \cdot 5 \cdot 6_2$
T_6 (4, 3m)	4	10	20	34	54	87	114	139	188	244	$4 \cdot 10_4 \cdot 4 \cdot 10_4 \cdot 4 \cdot 10_4$
T_7 (4, 3m)	4	10	16	30	49	77	100	138	181	214	$4 \cdot 6_2 \cdot 4 \cdot 6_2 \cdot 4 \cdot 6_2$
T_8 (4, 3m)	4	12	22	31	52	74	112	142	166	204	$5 \cdot 6_2 \cdot 5 \cdot 6_2 \cdot 5 \cdot 6_2$

Secondary building units: combinations only

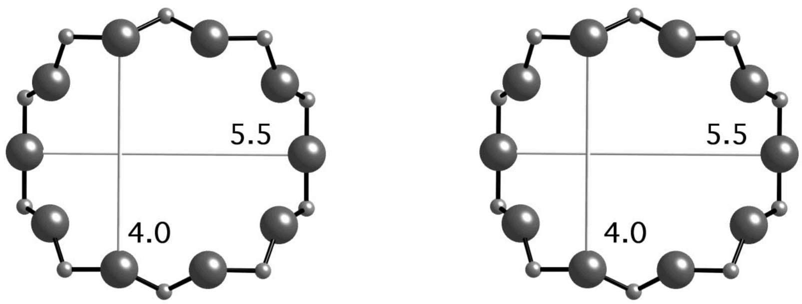
Loop configuration of T-Atoms:



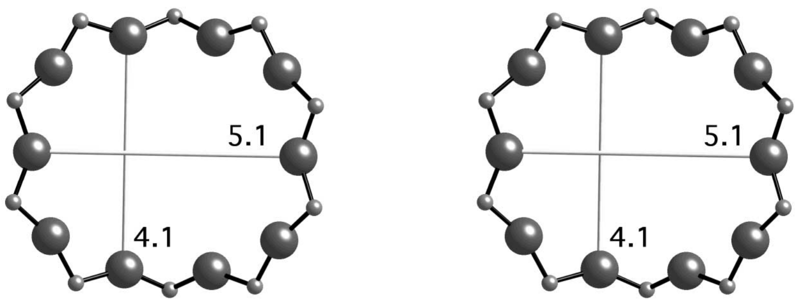
Crystal chemical data: $|H^{+}_{2.4}Na^{+}_{3.1}|$ **[**$Al_{0.4}B_{5.1}Si_{66.5}O_{144}$**]-MWW**
hexagonal, P6/mmm, a = 14.208Å, c = 24.945Å [4]

Framework density: 16.5 T/1000Å^3

Channels: ⊥ [001] **10** 4.0 x 5.5** | ⊥ [001] **10** 4.1 x 5.1**



10-ring viewed normal to [001]
between layers



10-ring viewed normal to [001]
within layers

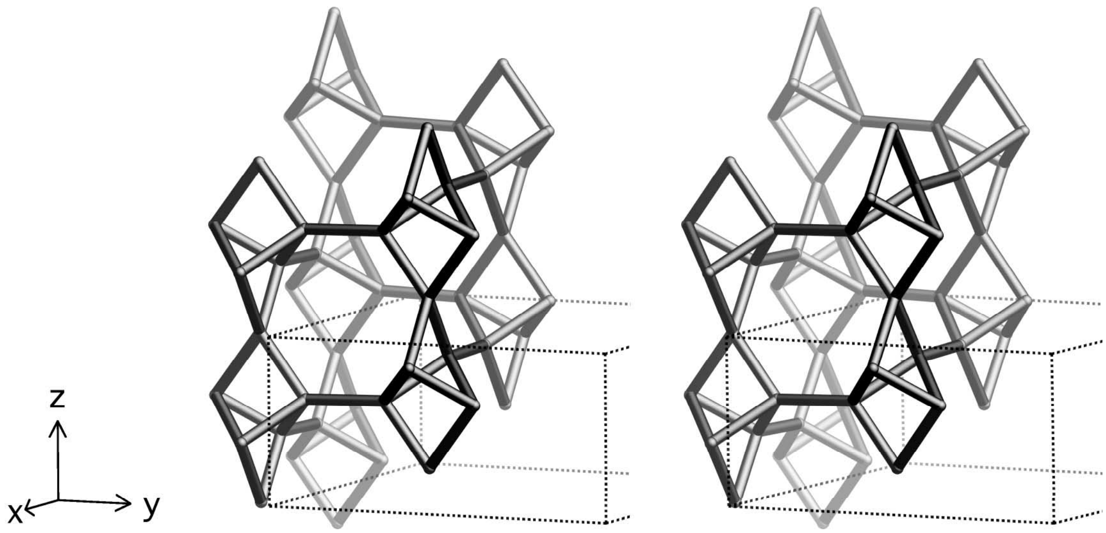
Isotypic framework structures:

*MCM-22[1]
ERB-1[2]
ITQ-1[3,4]
PSH-3[5]
SSZ-25[6]

References:

(1) Leonowicz, M.E., Lawton, J.A., Lawton, S.L. and Rubin, M.K. *Science*, **264**, 1910-1913 (1994)
(2) Belussi, G., Perego, G., Clerici, M.G. and Giusti, A. *Eur. Pat. Appl. EPA 293032* (1988)
(3) Camblor, M.A., Corell, C., Corma, A., Díaz-Cabañas, M.J., Nicolopoulos, S., González-Calbet, J.M. and Vallet-Regí, M. *Chem. Mater.*, **8**, 2415-2417 (1996)
(4) Camblor, M.A., Corma, A., Díaz-Cabañas, M.J. and Baerlocher, Ch. *J. Phys. Chem. B*, **102**, 44-51 (1998)
(5) Puppe, L. and Weisser, J. *U.S. Patent 4,439,409* (1984)
(6) Zones, S.I. *E. Patent 231,860* (1987)

NAT Framework Type $I4_1/amd$



framework viewed normal to [001]

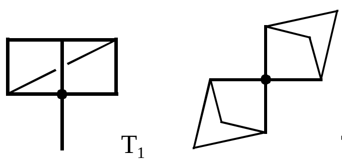
Idealized cell constants: tetragonal, $I4_1/amd$ (origin choice 2), a = 13.9Å, c = 6.4Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	9	19	35	52	78	106	139	179	213	$4\cdot8_2\cdot4\cdot8_2\cdot4_2\cdot8_4$
T_2 (4, $\bar{4}$m2)	4	8	18	36	56	66	116	140	154	232	$4_2\cdot4_2\cdot8_4\cdot8_4\cdot8_4\cdot8_4$

Secondary building units: 4=1

Loop configuration of T-Atoms:



T_1 T_2

Isotypic framework structures:

*Natrolite[1,2]
[Al-Ge-O**]-NAT**[3]
[Ga-Si-O**]-NAT**[4]
|Rb-**|[**Ga-Ge-O**]-NAT**[5]
Gonnardite[6]
High natrolite[7]
Mesolite[8]
Metanatrolite[9]
Scolecite[10-12]
Synthetic gonnardite[13]
Synthetic mesolite[14]
Synthetic natrolite[14]
Synthetic scolecite[14]

Alternate designation: Laubanite (discredited)

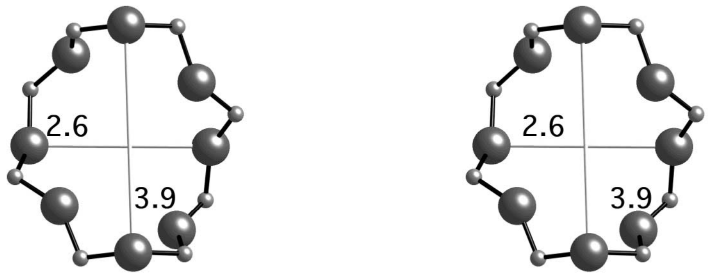
References:

(1) Pauling, L. *Proc. Natl. Acad. Sci.*, **16**, 453-459 (1930)
(2) Meier, W.M. *Z. Kristallogr.*, **113**, 430-444 (1960)
(3) Tripathi, A., Johnson, G.M., Kim, S.J. and Parise, J.B. *J. Mater. Chem.*, **10**, 451-455 (2000)
(4) Xie, D., Newsam, J.M., Yang, J. and Yelong, W.B. In *MRS Sym. Proc.*, (eds. M.M.J. Treacy, J.M. White and J.M. Thomas), **111**, pp. 147-154 (1988), Materials Research Society, Pittsburgh, PA

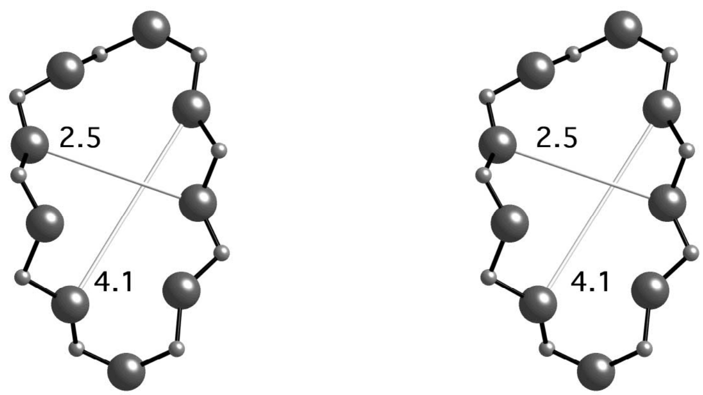
Crystal chemical data: |Na^{+}_{16} $(H_2O)_{16}$| **[**$Al_{16}Si_{24}$ O_{80}**]-NAT**
orthorhombic, Fdd2, a = 18.30Å, b = 18.63Å, c = 6.60Å [(2)]
(Relationship to unit cell of Framework Type: a' = b' = a·sqrt(2), c' = c
or, as vectors, **a'** = **a** + **b**, **b'** = **b** - **a**, **c'** = **c**)

Framework density: 17.8 T/1000Å^3

Channels: <100> **8** 2.6 x 3.9** ↔ [001] **9** 2.5 x 4.1* (variable due to considerable flexibility of framework)



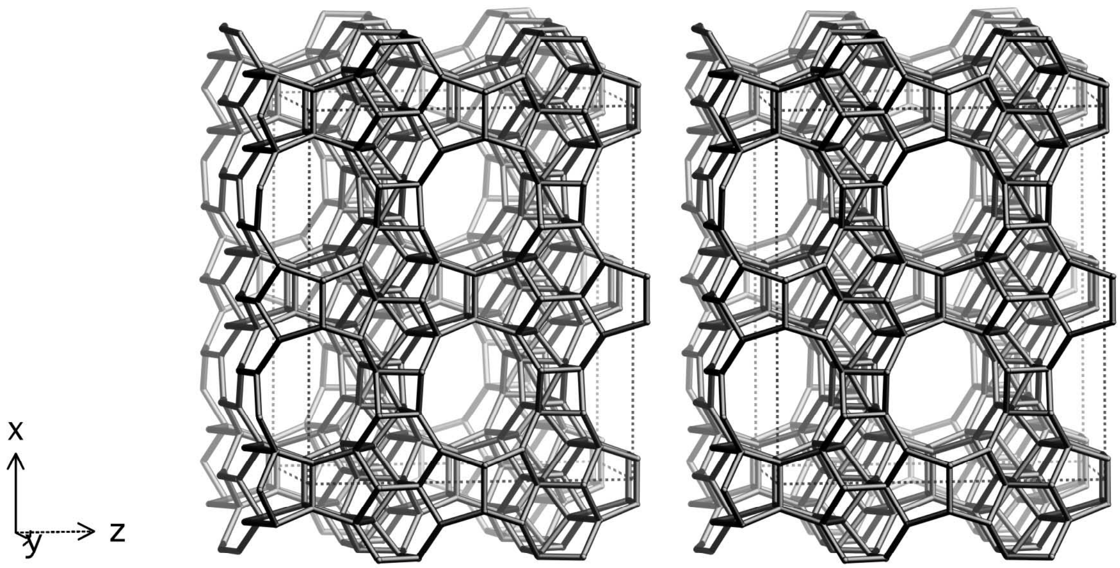
8-ring viewed along <100>



9-ring viewed along [001] (variable)

References (cont.):

(5) Klaska, K.H. and Jarchow, O. *Z. Kristallogr.*, **172**, 167-174 (1985)
(6) Mazzi, F., Larsen, A.O., Gottardi, G. and Galli, E. *N. Jb. Miner. Mh.*, 219-228 (1986)
(7) Baur, W.H. and Joswig, W. *N. Jb. Miner. Mh.*, 171-187 (1996)
(8) Artioli, G., Smith, J.V. and Pluth, J.J. *Acta Crystallogr.*, **C42**, 937-942 (1986)
(9) Joswig, W. and Baur, W.H. *N. Jb. Miner. Mh.*, 26-38 (1995)
(10) Taylor, W.H. and Jackson, R. *Z. Kristallogr.*, **86**, 53-64 (1933)
(11) Fälth, L. and Hansen, S. *Acta Crystallogr.*, **B35**, 1877-1880 (1979)
(12) Smith, J.V., Pluth, J.J., Artioli, G. and Ross, F.K. In *Proc. 6th Int. Zeolite Conf.*, (eds. D.H. Olson and A. Bisio), pp. 842-850 (1984), Butterworths, Guildford, Surrey
(13) Ghobarkar, H. and Schaef, O. *Zeolites*, **19**, 259-261 (1997)
(14) Ghobarkar, H. and Schaef, O. *Cryst. Res. Technol.*, **31**, K67-69 (1996)



framework viewed along [010]

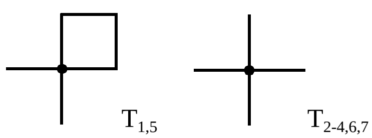
Idealized cell constants: orthorhombic, Fmmm, a = 26.1Å, b = 13.9Å, c = 22.9Å

Coordination sequences and vertex symbols:

T_1 (32, 1)	4	11	21	36	58	89	123	157	187	237	$4·6·5·5·5_2·10$
T_2 (32, 1)	4	12	22	38	57	86	118	152	196	245	$5·5·5·6_2·5·10$
T_3 (16, m)	4	12	20	34	57	88	125	158	192	224	$5·5_2·5·5_2·12_2·*$
T_4 (16, m)	4	12	20	31	57	84	118	150	187	237	$5·5·5·5·5·6_2$
T_5 (16, m)	4	11	24	40	63	86	114	158	208	255	4·10·5·5·5·5
T_6 (16, m)	4	12	22	35	55	83	119	151	184	237	$5·5_2·5·6·5·6$
T_7 (8, mm2)	4	12	24	32	50	88	120	152	180	226	$5·5·5·5·12_6·*$

Secondary building units: 5-3

Loop configuration of T-Atoms:



Isotypic framework structures: *NU-87[1]
Gottardiite[2]

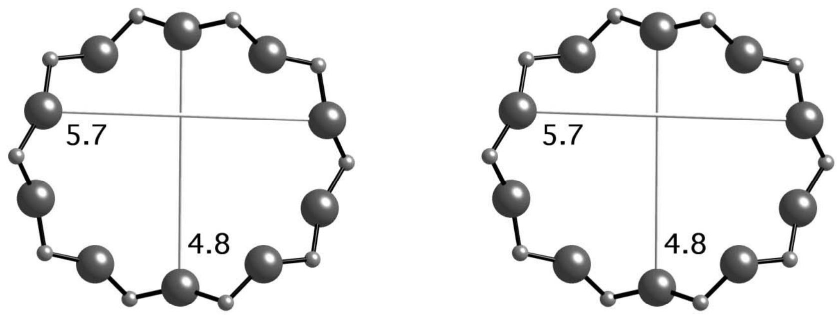
References:

(1) Shannon, M.D., Casci, J.L., Cox, P.A. and Andrews, S.J. *Nature*, **353**, 417-420 (1991)
(2) Alberti, A., Vezzalini, G., Galli, E. and Quartieri, S. *Eur. J. Mineral.*, **8**, 69-75 (1996)

Crystal chemical data: |H^+_4 $(H_2O)_n$| **[**Al_4Si_{64} O_{136}**]-NES**
monoclinic, $P12_1/c1$
a = 14.324Å, b = 22.376Å, c = 25.092Å, β = 151.51° [(1)]
(Relationship to unit cell of Framework Type:
a' = b/2sinβ , b' = c, c' = a
or, as vectors, **a'** = (**b - a**)/2, **b'** = **c**, **c'** = **a**)

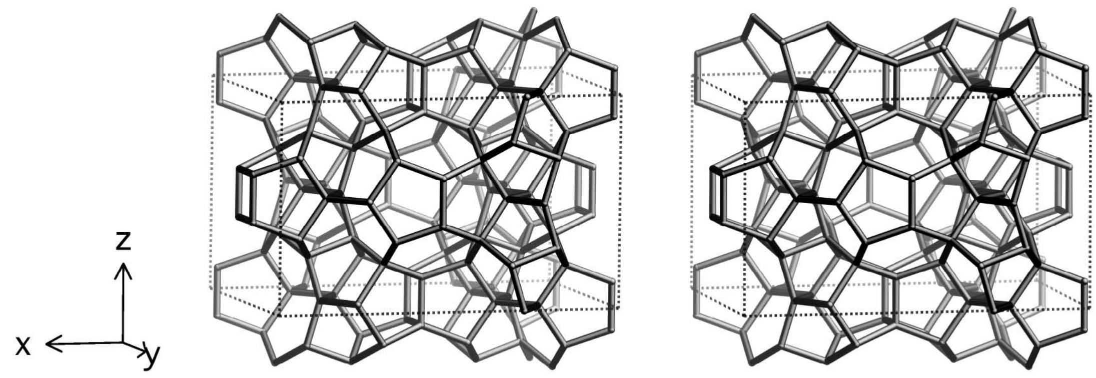
Framework density: 17.7 T/1000$Å^3$

Channels: [100] **10** 4.8 x 5.7**



10-ring along [100]

NON Framework Type Fmmm



framework viewed along [010]

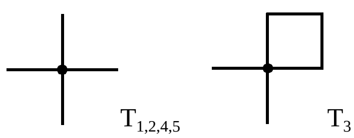
Idealized cell constants: orthorhombic, Fmmm, a = 22.9Å, b = 15.7Å, c = 13.9Å

Coordination sequences and vertex symbols:

T_1 (32, 1)	4	12	25	42	67	95	133	174	219	273	5·6·5·6·5·6
T_2 (16, m)	4	12	24	39	64	99	130	174	217	262	$5\cdot6\cdot5\cdot6\cdot5\cdot6_2$
T_3 (16, m)	4	11	23	44	72	95	124	170	229	279	4·6·5·5·5·5
T_4 (16, m)	4	12	24	41	65	97	133	173	212	267	$5\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_5 (8, 2mm)	4	12	24	40	62	92	142	166	214	262	$5\cdot5\cdot5\cdot5\cdot12_2\cdot*$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:

*Nonasil[1]
[B-Si-O**]-NON**[2]
|(Co(C_5H_5)$_2$)$_4$ F_4| **[**$Si_{88}O_{176}$**]-NON**[3]
CF-3[4]
ZSM-51[5]

References:

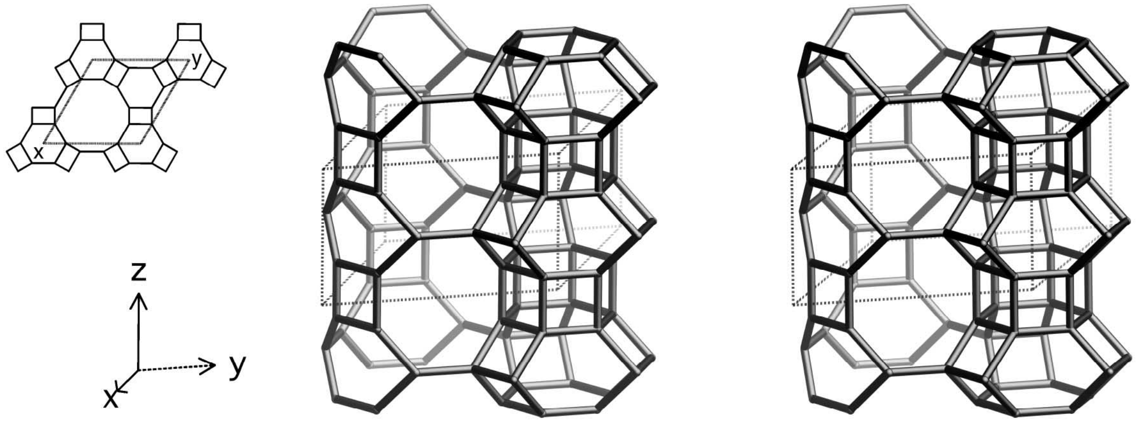
(1) Marler, B., Dehnbostel, N., Eulert, H.-H., Gies, H. and Liebau, F. *J. Incl. Phenom.*, **4**, 339-349 (1986)
(2) Marler, B. and Gies, H. *Zeolites*, **15**, 517-525 (1995)
(3) Vandegoor, G., Freyhardt, C.C. and Behrens, P. *Z. anorg. allg. Chemie*, **621**, 311-322 (1999)
(4) Long,Y.-C., Zhong, W. and Shen, X. *J. Incl. Phenom.*, **4**, 121-127 (1986)
(5) Rohrbaugh, W.J. *private communication*

Crystal chemical data: **|**$(C_5H_{13}N)_4$**|** **[**Si_{88} O_{176}**]-NON**
$C_5H_{13}N$ = 2-aminopentane
orthorhombic, Fmmm, a = 22.232Å, b = 15.058Å, c = 13.627Å [(1)]

Framework density: 19.3 T/1000$Å^3$

Channels: apertures formed by 6-rings only

OFF Framework Type $P\bar{6}m2$



framework viewed normal to [001] (top left: projection down [001])

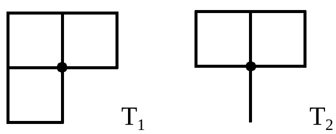
Idealized cell constants: hexagonal, $P\bar{6}m2$, a = 13.1Å, c = 7.6Å

Coordination sequences and vertex symbols:

Coordination sequences and vertex symbols:	T_1 (12, 1)	4	9	17	30	50	75	98	118	144	185	4·4·4·6·6·8
	T_2 (6, m)	4	10	20	32	46	66	94	128	162	192	4·8·4·8·6·6

Secondary building units: 6

Loop configuration of T-Atoms:



Framework description: AAB sequence of 6-rings

Isotypic framework structures:
*Offretite[1,2]
LZ-217[3]
Linde T (**ERI-OFF** structural intermediate)[4]
Synthetic offretite[5]
TMA-O[6]

References:

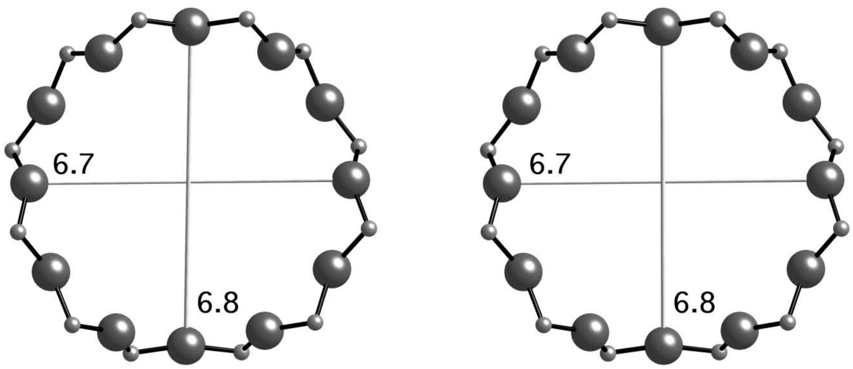
(1) Bennett, J.M. and Gard, J.A. *Nature* , **214**, 1005-1006 (1967)
(2) Gard, J.A. and Tait, J.M. *Acta Crystallogr.*, **B28**, 825-834 (1972)
(3) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023* (1985)
(4) Breck, D.W. *Zeolite Molecular Sieves*, p. 173 (1974), Wiley, New York
(5) Ghobarkar, H. and Schaef, O. *Cryst. Res. Technol.*, **31**, K29-31 (1996)
(6) Aiello, R., Barrer, R.M., Davies, J.A. and Kerr, I.S. *Trans. Faraday Soc.*, **66**, 1610-1617 (1970)

Offretite — Type Material — OFF

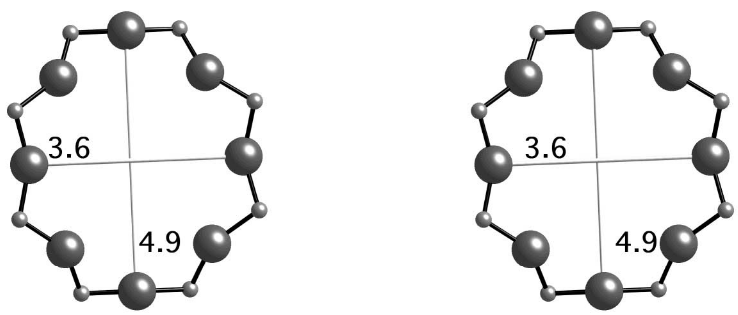
Crystal chemical data: **|**$(Ca^{2+},Mg^{2+})_{1.5}K^{+}\ (H_2O)_{14}$**| [**$Al_4Si_{14}\ O_{36}$**]-OFF**
hexagonal, $P\bar{6}m2$, a = 13.291Å, c = 7.582Å [(2)]

Framework density: 15.5 T/1000Å^3

Channels: [001] **12** 6.7 x 6.8* ↔ ⊥ [001] **8** 3.6 x 4.9**

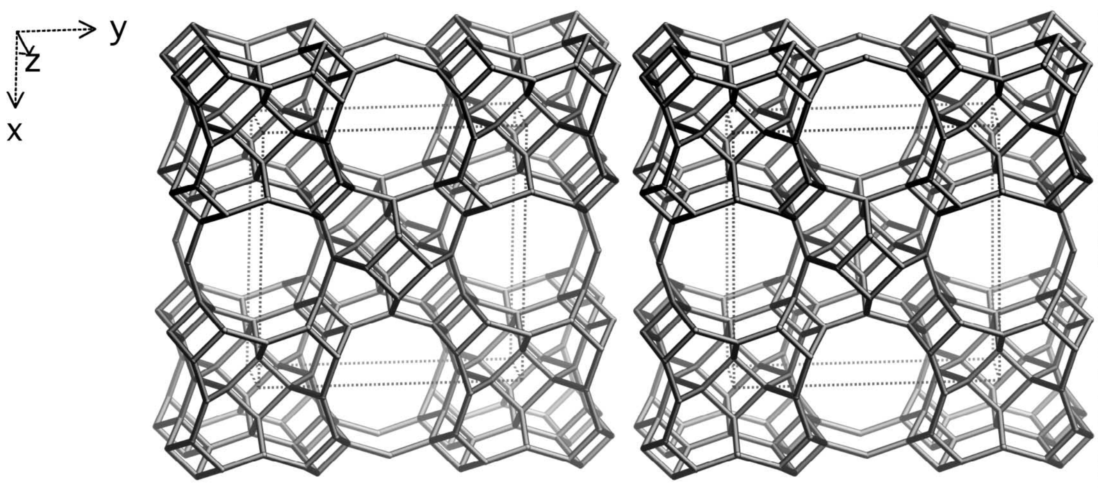


12-ring viewed along [001]



8-ring viewed normal to [001]

OSI   Framework Type   I4/mmm



framework viewed along [001]

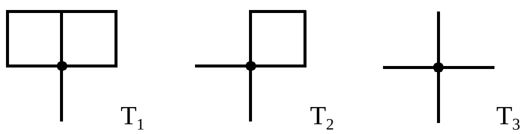
Idealized cell constants: tetragonal, I4/mmm, a = 18.5Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	10	21	37	57	82	111	145	189	236	$4\cdot6\cdot4\cdot6\cdot6\cdot6_2$
T_2 (8, m2m)	4	11	22	34	52	84	120	149	180	220	$4\cdot6_2\cdot6_2\cdot6_2\cdot6_2\cdot6_2$
T_3 (8, m2m)	4	12	22	37	60	81	112	154	192	230	$6_2\cdot6_2\cdot6_2\cdot6_2\cdot6_2\cdot12_6$

Secondary building units: 6-2

Loop configuration of T-Atoms:



Isotypic framework structures: *UiO-6[1]

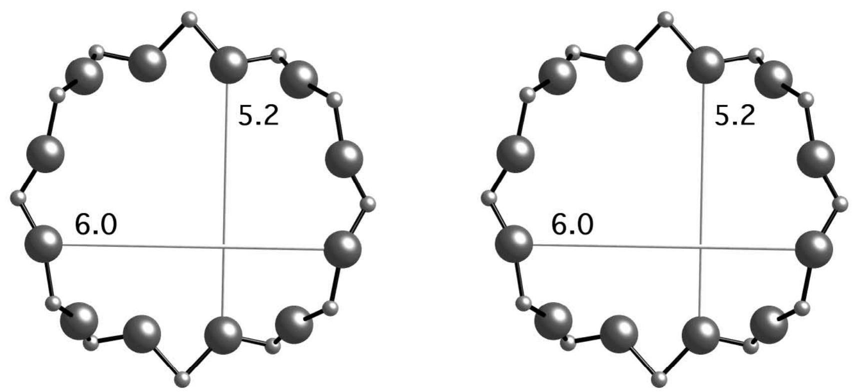
References:

(1) Akporiaye, D.E., Fjellvåg, H., Halvorsen, E.N., Haug, T., Karlsson, A. and Lillerud, K.P. *Chem. Commun.*, 1553-1554 (1996)

Crystal chemical data: **[**$Al_{16}P_{16}O_{64}$**]-OSI**
orthorhombic, Imm2, a = 18.355Å, b = 18.321Å, c = 5.053Å [(1)]

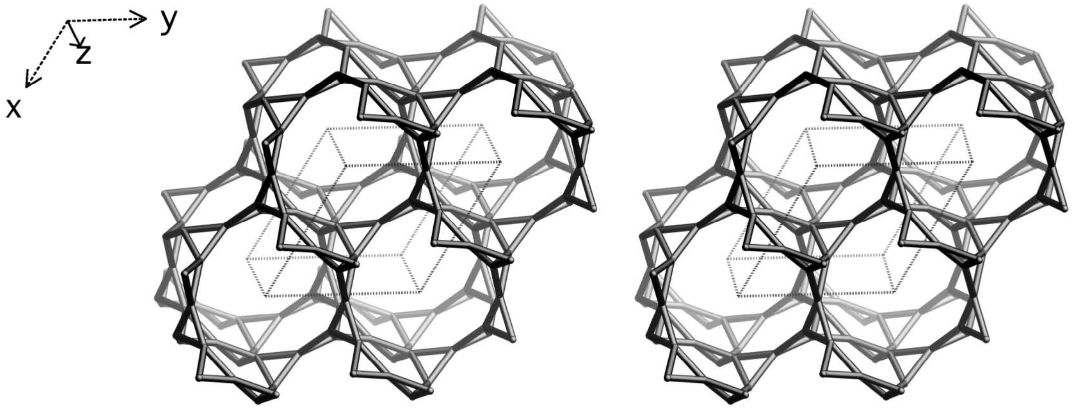
Framework density: 18.8 T/1000Å^3

Channels: [001] **12** 5.2 x 6.0*



12-ring viewed along [001]

OSO Framework Type $P6_222$



framework viewed along [001]

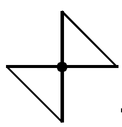
Idealized cell constants: hexagonal, $P6_222$, a = 10.1Å, c = 7.6Å

Coordination sequences and vertex symbols:

T_1 (6, 2)	4	8	16	29	46	70	101	118	162	190	$3\cdot3\cdot8\cdot8\cdot8\cdot14_{10}$
T_2 (3, 222)	4	8	16	30	44	76	92	130	148	202	$3\cdot3\cdot8\cdot8\cdot14_7\cdot14_7$

Secondary building units: 3

Loop configuration of T-Atoms:



$T_{1,2}$

Isotypic framework structures: *OSB-1[1]

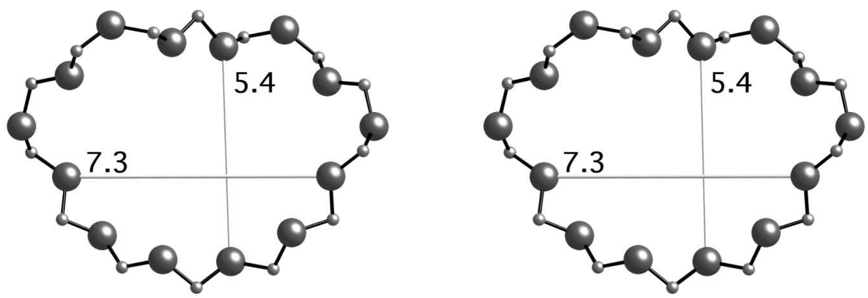
References:

(1) Kongshaug, K.O., Fjellvåg, H., Lillerud, K.P., Gier, T.E., Stucky, G.D. and Cheetham, A.K. *private communication*

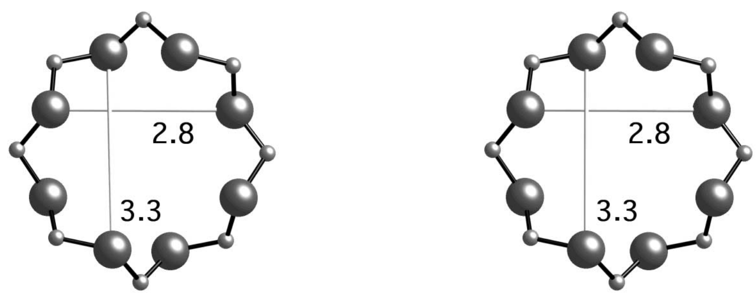
Crystal chemical data: |K^+_6 $(H_2O)_9$| **[**Be_3Si_6 O_{18}**]-OSO**
trigonal, $P3_2$, a = 10.093Å, c = 7.626Å [(1)]

Framework density: 13.4 T/1000Å^3

Channels: [001] **14** 5.4 x 7.3* ↔ ⊥ [001] **8** 2.8 x 3.3**

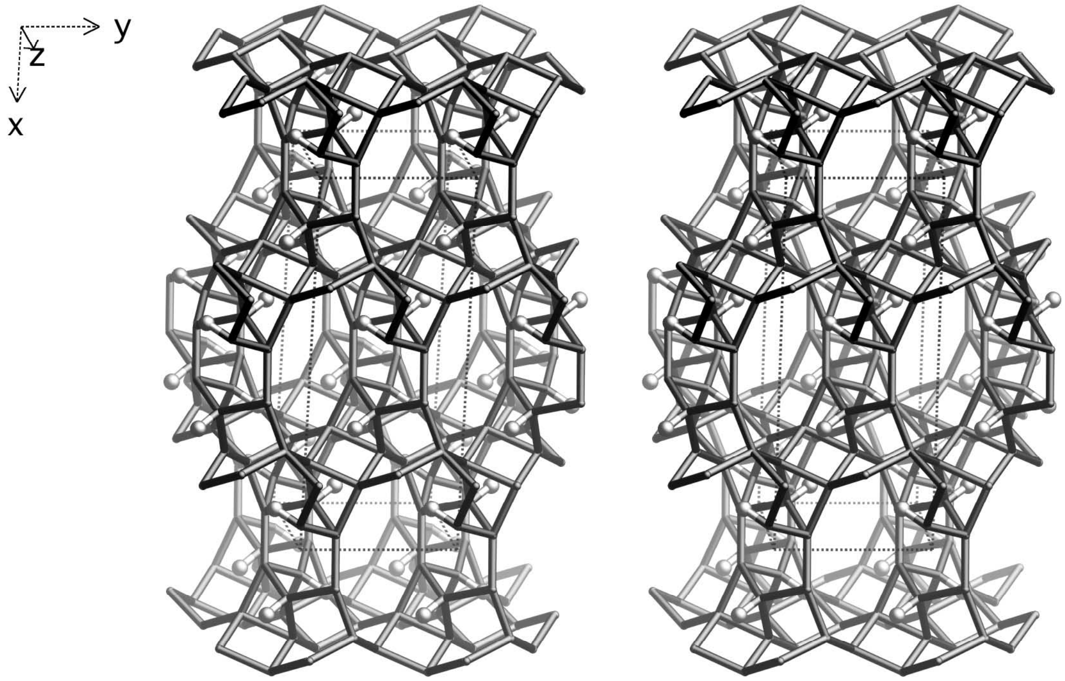


puckered 14-ring viewed along [001]



8-ring viewed normal to [001]

-PAR Framework Type C2/c



framework viewed along [001]

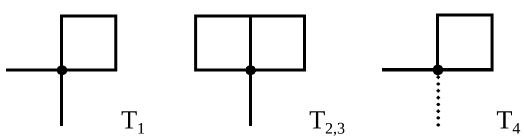
Idealized cell constants: monoclinic, C2/c, a = 20.9Å, b = 9.2Å, c = 8.6Å, β = 89.7°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	18	31	48	71	99	132	162	197	$4·6·6·6·6·10_2$
T_2 (8, 1)	4	9	19	33	51	77	96	126	162	203	$4·6·4·8_2·6·6_2$
T_3 (8, 1)	4	10	19	33	52	72	102	126	161	204	$4·6_2·4·8_2·8_2·10$
T_4 (8, 1)	3	8	16	29	49	68	94	123	162	203	$4·6·6_2$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Partheite[1]

References:

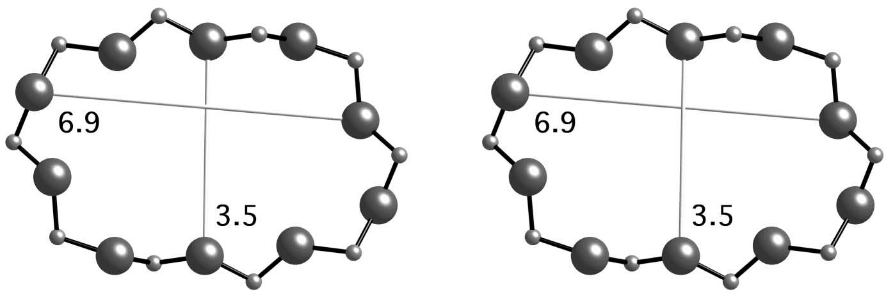
(1) Engel, N. and Yvon, K. *Z. Kristallogr.*, **169**, 165-175 (1984)

Crystal chemical data: |Ca^{2+}_8 $(H_2O)_{16}$| [$Al_{16}Si_{16}$ $O_{60}(OH)_8$]- **-PAR**
monoclinic, C2/c, a = 21.555Å, b = 8.761Å, c = 9.304Å, β = 91.55° (1)

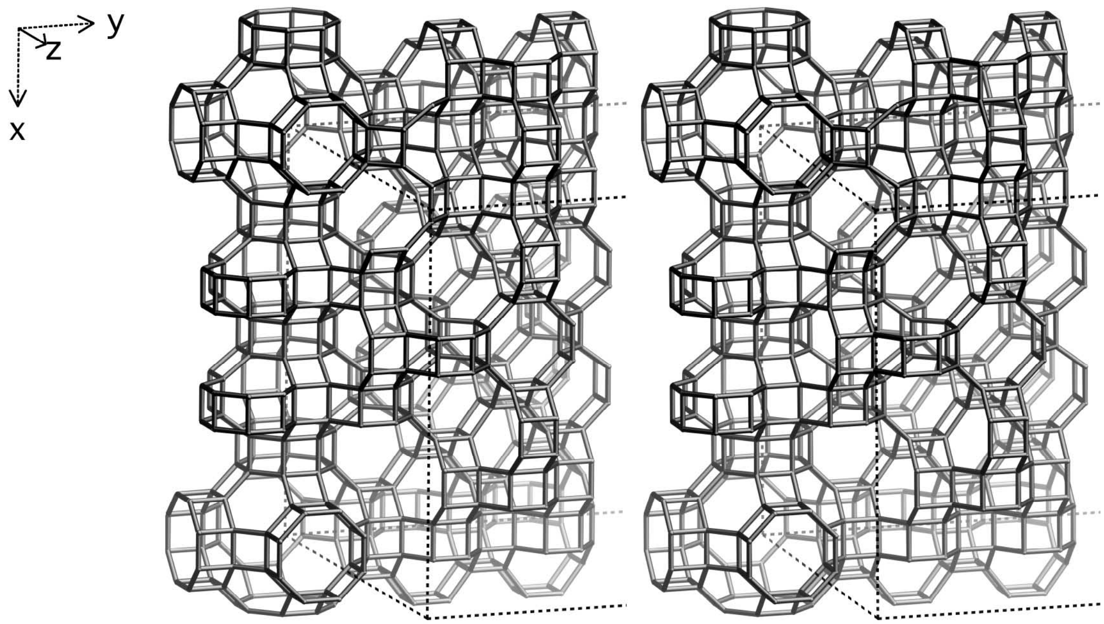
Framework density: 18.2 T/1000$Å^3$

Channels: [001] **10** 3.5 x 6.9*

Stability: Stable at 150ºC, transforms at 400ºC (1)



10-ring viewed along [001]



framework viewed along [001]

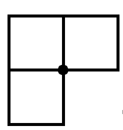
Idealized cell constants: cubic, $Im\bar{3}m$, a = 34.8Å

Coordination sequences and vertex symbols:

T_1 (96, 1)	4	9	18	31	47	68	91	117	151	188	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_2 (96, 1)	4	9	18	32	49	70	95	122	154	191	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_3 (96, 1)	4	9	18	32	49	69	94	123	153	186	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_4 (96, 1)	4	9	18	32	48	67	92	121	152	185	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_5 (96, 1)	4	9	18	31	47	68	92	119	152	188	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_6 (96, 1)	4	9	17	29	45	65	89	117	149	185	$4\cdot4\cdot4\cdot6\cdot8\cdot8$
T_7 (48, 2)	4	9	17	30	47	66	88	113	144	183	$4\cdot4\cdot4\cdot6\cdot8\cdot8$
T_8 (48, 2)	4	9	18	32	49	69	95	123	152	188	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$

Secondary building units: 4

Loop configuration of T-Atoms:



T_{1-8}

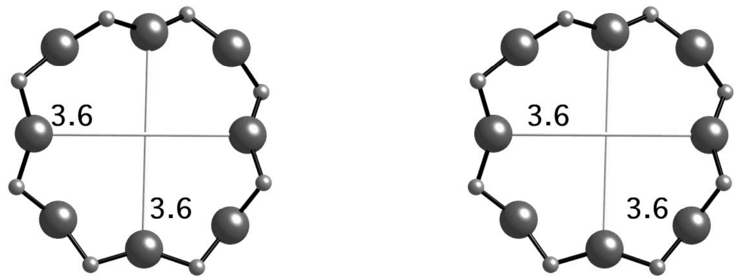
Isotypic framework structures:
*Paulingite(1)
ECR-18(2)

References:
(1) Gordon, E.K., Samson, S. and Kamb, W.K. *Science*, **154**, 1004-1007 (1966)
(2) Vaughan, D.E.W. and Strohmaier, G. *U.S. Patent 4,661,332* (1987)

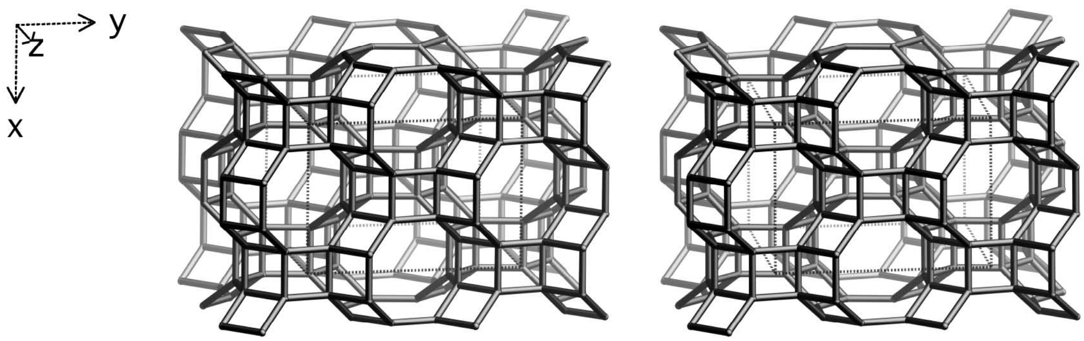
Crystal chemical data: |$(Ca^{2+},K^{+}_{2},Na^{+}_{2})_{76}$ $(H_2O)_{700}$| [$Al_{152}Si_{520}$ O_{1344}]-**PAU**
cubic, Im$\bar{3}$m, a = 35.093Å [(1)]

Framework density: 15.5 T/1000Å^3

Channels: <100> **8** 3.6x3.6*** | <100> **8** 3.6 x 3.6***



8-ring viewed along <100>



framework viewed along [001]

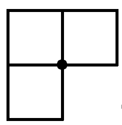
Idealized cell constants: orthorhombic, Cmcm, a = 9.9Å, b = 14.1Å, c = 14.0Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	18	32	50	71	94	122	157	195	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$
T_2 (16, 1)	4	9	18	32	48	68	96	126	155	191	$4\cdot4\cdot4\cdot8_2\cdot8\cdot8$

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



$T_{1,2}$

Isotypic framework structures:
*Phillipsite[1,2]
[Al-Co-P-O**]-PHI**[3]
Harmotome[2,4]
ZK-19[6]

Alternate designation: Wellsite[5] (discredited)

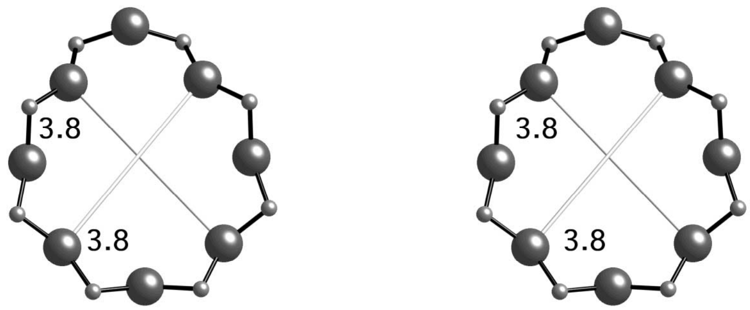
References:

(1) Steinfink, H. *Acta Crystallogr.*, **15**, 644-651 (1962)
(2) Rinaldi, R., Pluth, J.J. and Smith, J.V. *Acta Crystallogr.*, **B30**, 2426-2433 (1974)
(3) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(4) Sadanaga, R., Marumo, F. and Yakéuchi, Y. *Acta Crystallogr.*, **14**, 1153-1163 (1961)
(5) Cerny, P., Rinaldi, R. and Surdam, R.C. *N. Jb. Miner. Abh.*, **128**, 312-330 (1977)
(6) Kuehl, G.H. *Am. Mineral.*, **54**, 1607-1612 (1969)

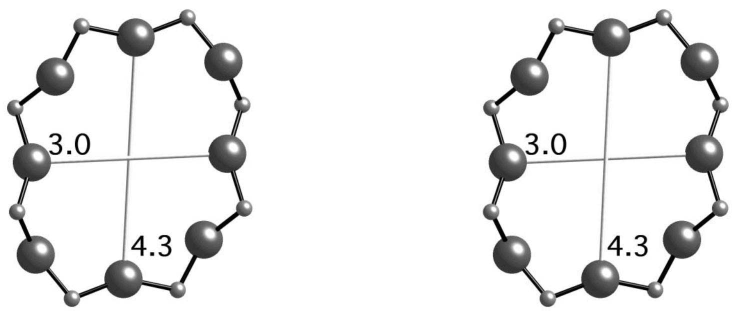
Crystal chemical data: $|K^{+}_{2}(Ca^{2+},Na^{+}_{2})_{2}\ (H_{2}O)_{12}|$ **[**$Al_{6}Si_{10}\ O_{32}$**]-PHI**
monoclinic, $P12_{1}/m1$
a = 9.865Å, b = 14.300Å, c = 8.668Å, β = 124.20° [2]
(Relationship to unit cell of Framework Type:
a' = a, b' = c, c' = b/2sin(β)
or, as vectors, **a'** = **a**, **b'** = **c**, **c'** = (**b** - **a**)/2)

Framework density: 15.8 T/1000Å^{3}

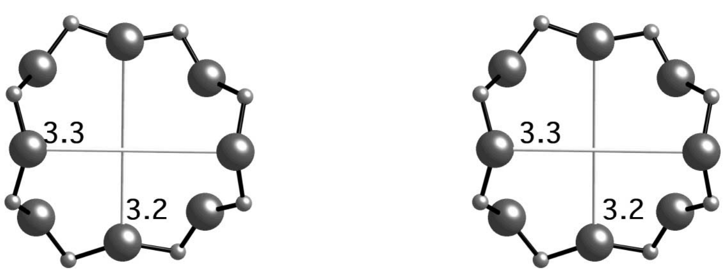
Channels: [100] **8** 3.8 x 3.8* ↔ [010] **8** 3.0 x 4.3* ↔ [001] **8** 3.2 x 3.3*



8-ring viewed along [100]

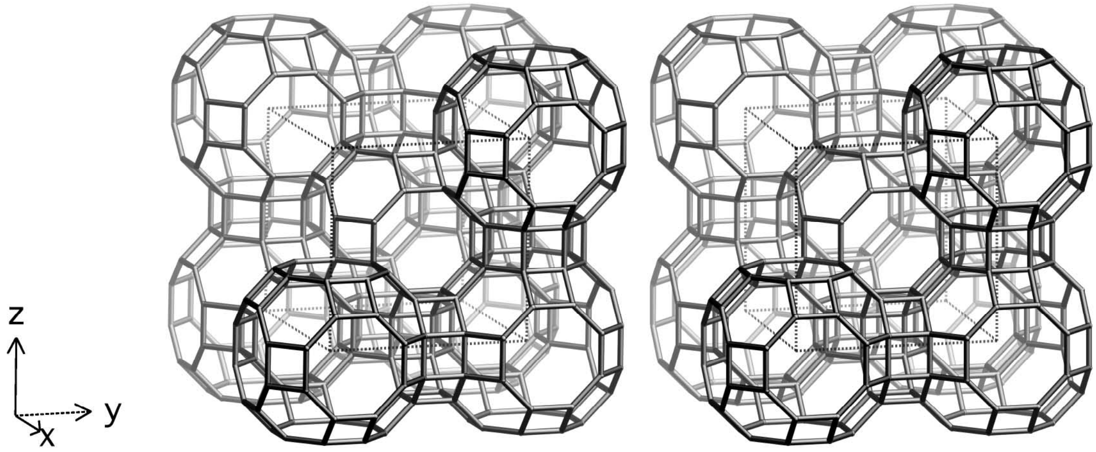


8-ring viewed along [010]



8-ring viewed along [001]

RHO Framework Type $Im\bar{3}m$



framework viewed along [100]

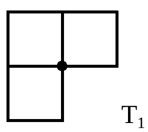
Idealized cell constants: cubic, $Im\bar{3}m$, a = 14.9Å

Coordination sequences and vertex symbols:

T_1 (48, 2)	4	9	17	28	42	60	81	105	132	162	4·4·4·6·8·8

Secondary building units: 8-8 or 6-2 or 8 or 6 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:

*Rho[1,2]
[Be-As-O**]-RHO**[3]
[Be-P-O**]-RHO**[4]
[Co-Al-P-O**]-RHO**[5]
[Mg-Al-P-O**]-RHO**[5]
[Mn-Al-P-O**]-RHO**[5]
Deuterated Rho[6]
Gallosilicate ECR-10[7]
LZ-214[8]
Pahasapaite[9.10]

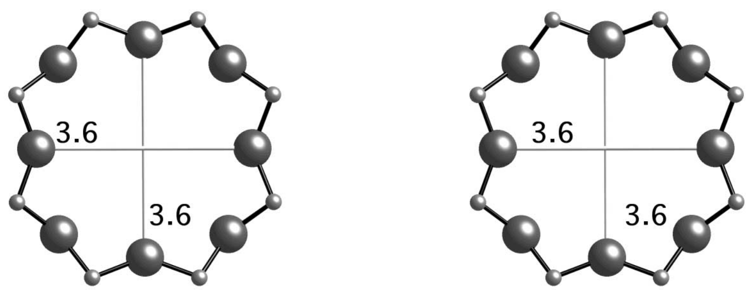
References:

(1) Robson, H.E., Shoemaker, D.P., Ogilvie, R.A. and Manor, P.C. *Adv. Chem. Ser.* , **121**, 106-115 (1973)
(2) McCusker, L.B. and Baerlocher, Ch. In *Proc. 6th Int. Zeolite Conf.*, (eds. D.H. Olson and A. Bisio), pp. 812-822 (1984), Butterworths, Guildford, Surry
(3) Gier, T.E. and Stucky, G.D. *Nature*, **349**, 508-510 (1991)
(4) Harvey, G. and Meier, W.M. *Stud. Surf. Sci. Catal.*, **49**, 411-420 (1989)
(5) Feng, P., Bu, X. and Stucky, G.D. *Microporous and Mesoporous Materials*, **23**, 315-322 (1998)
(6) Parise, J.B., Gier, T.E., Corbin, D.R. and Cox, D.E. *J. Phys. Chem.*, **88**, 1635-1640 (1984)
(7) Newsam, J.M., Vaughan, D.E.W. and Strohmaier, K.G. *J. Phys. Chem.*, **99**, 9924-9932 (1995)
(8) Breck, D.W. and Skeels, G.W. *U.S. Patent 4,503,023*, (1985)
(9) Rouse, R.C., Peacor, D.R., Dunn, P.J., Campbell, T.J., Roberts, W.L., Wicks, F.J. and Newbury, D. *N. Jb. Miner. Mh.*, 433-440 (1987)
(10) Rouse, R.C., Peacor, D.R. and Merlino, S. *Am. Mineral.*, **74**, 1195-1202 (1989)

Crystal chemical data: |$(Na^+,Cs^+)_{12}$ $(H_2O)_{44}$| [$Al_{12}Si_{36}$ O_{96}]-**RHO**
cubic, Im$\overline{3}$m, a = 15.031Å [(2)]

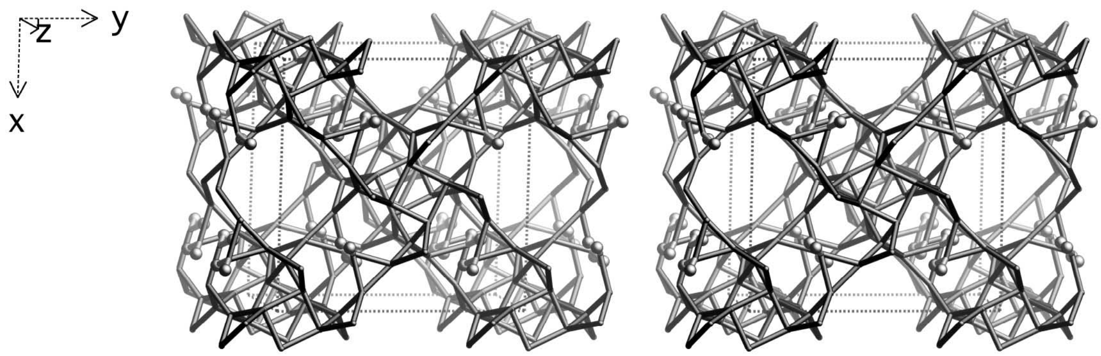
Framework density: 14.1 T/1000Å^3

Channels: <100> **8** 3.6 x 3.6*** | <100> **8** 3.6 x 3.6***



8-ring viewed along <100>

-RON Framework Type I4/mcm



framework viewed along [001]

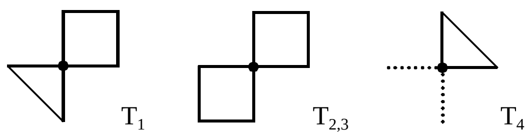
Idealized cell constants: tetragonal, I4/mcm, a = 18.1Å, c = 9.0Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	7	17	31	49	76	98	125	170	208	$3 \cdot 4 \cdot 10_4 \cdot * \cdot 10_4 \cdot *$
T_2 (16, m)	4	10	20	31	47	78	109	127	162	212	$4 \cdot 4 \cdot 6 \cdot 6 \cdot 6 \cdot 6$
T_3 (16, 2)	4	10	16	31	56	67	94	146	164	188	$4 \cdot 4 \cdot 6_2 \cdot 10_4 \cdot 10_2 \cdot 10_2$
T_4 (8, m2m)	2	4	10	24	38	58	91	110	138	194	3

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *Roggianite[1]

The previously reported structure (the ROG type) was found to be incomplete and the code –ROG has been discredidted based on a decision by the IZA Structure commission.

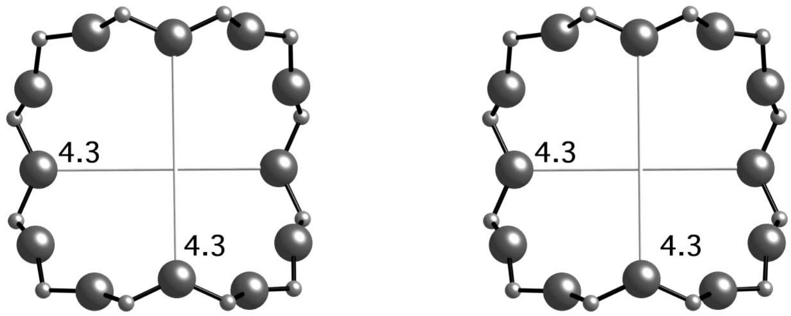
References:

(1) Giuseppetti, G., Mazzi, F., Tadini, C. and Galli, E. *N. Jb. Miner. Mh.*, 307-314 (1991)

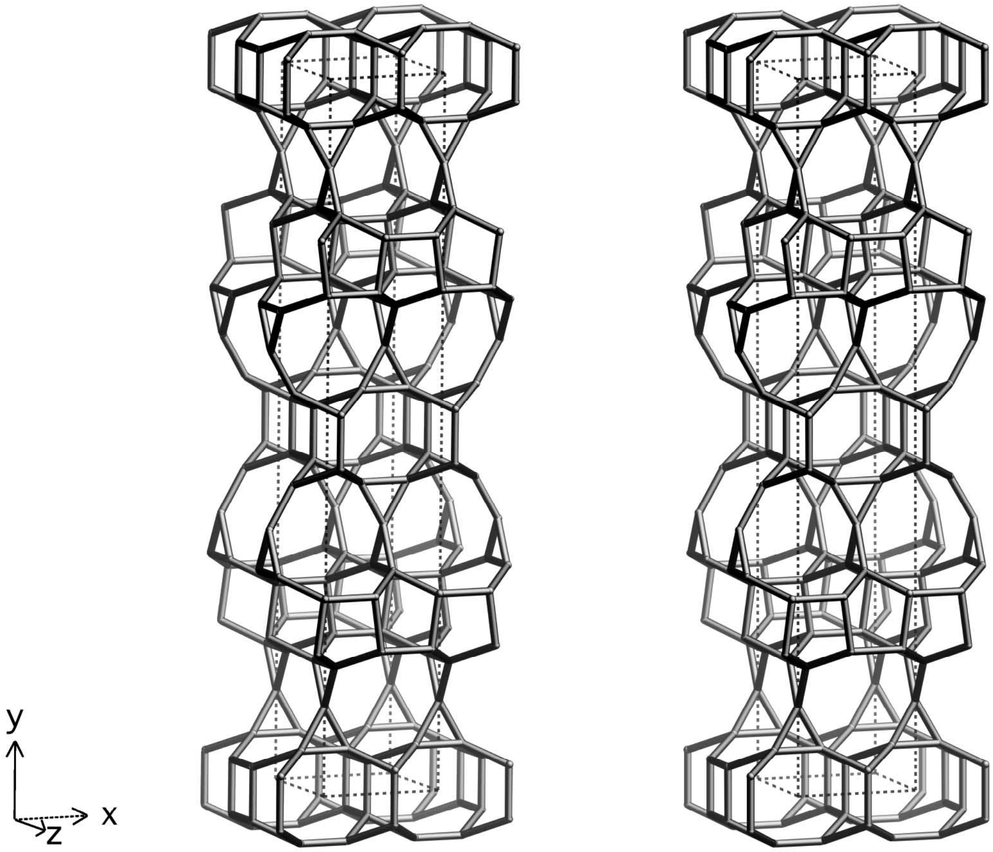
Crystal chemical data: **|**Ca^{2+}_{16} $(H_2O)_{19}$**| [**$Be_8Al_{16}Si_{32}$ $O_{104}(OH)_{16}$**]- -RON**
tetragonal, I4/mcm, a = 18.33Å, c = 9.16Å [(1)]

Framework density: 18.2 T/1000$Å^3$

Channels: [001] **12** 4.3 x 4.3*



12-ring viewed along [001]



framework viewed along [001]

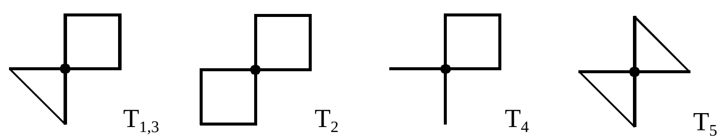
Idealized cell constants: monoclinic, C2/m, a = 7.2Å, b = 41.8Å, c = 7.2Å, γ= 90.0°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	9	19	39	59	78	117	155	189	235	$3·4·8_3·9_4·8_3·9_4$
T_2 (8, 1)	4	10	21	37	58	91	117	144	194	241	$4·4·6_2·8·6_2·8$
T_3 (8, 1)	4	9	21	42	57	82	119	151	188	239	$3·4·8_2·9_4·8_2·9_4$
T_4 (8, 1)	4	11	21	40	61	89	116	145	191	239	$4·5_2·5·8·5·8$
T_5 (4, 2)	4	8	20	44	55	80	118	152	204	228	$3·3·9_4·9_4·9_4·9_4$

Secondary building units: combinations only

Loop configuration of T-Atoms:



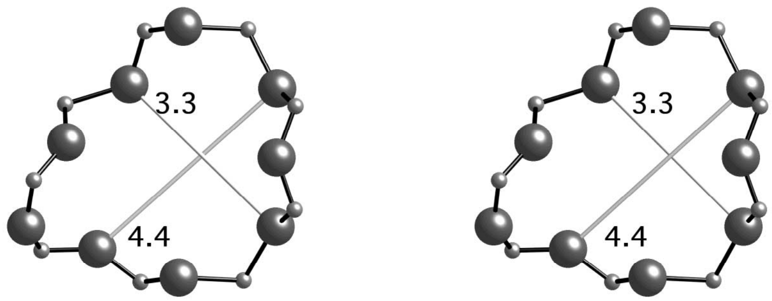
Isotypic framework structures: *RUB-17[1]

Crystal chemical data: |$K^+_4 Na^+_{12}$ $(H_2O)_{18}$| **[**$Zn_8 Si_{28}$ O_{72}**]-RSN**
monoclinic, C1m1, a = 7.238Å, b = 40.56Å, c = 7.308Å, β = 91.8° (1)

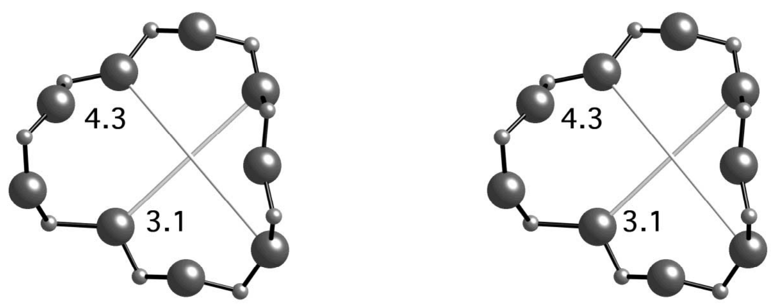
Framework density: 16.8 T/1000Å^3

Channels: [100] **9** 3.3 x 4.4* ↔ [001] **9** 3.1 x 4.3* ↔[010] **8** 3.4 x 4.1*

Stability: Complete dehydration leads to destruction of the framework (1)



9-ring viewed along [100]

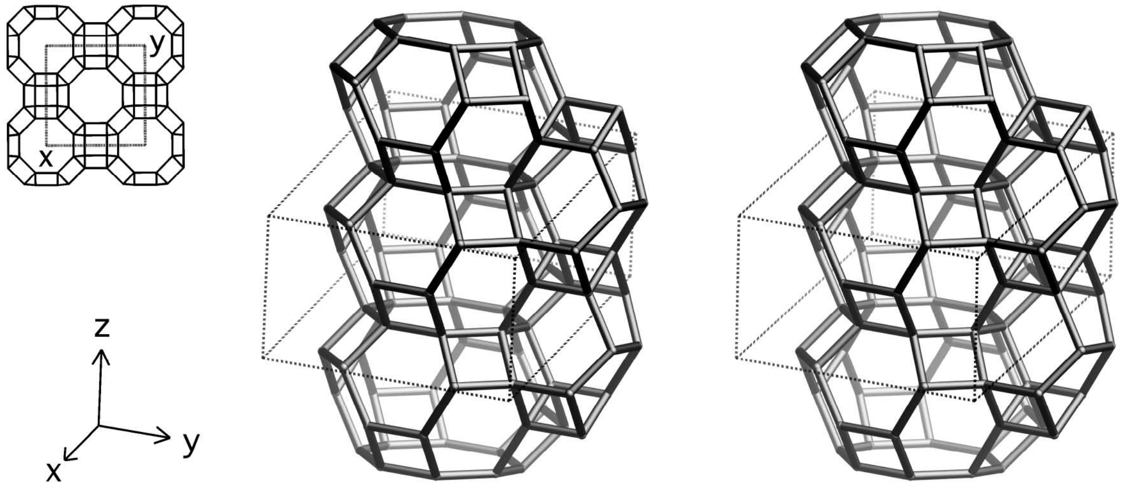


9-ring viewed along [001]

See Appendix A for 8-ring viewed along [010]

References:

(1) Röhrig, C. and Gies, H. *Angew. Chem., Int. Ed.*, **34**, 63-65 (1995)



framework viewed normal to [001] (top left: projection down [001])

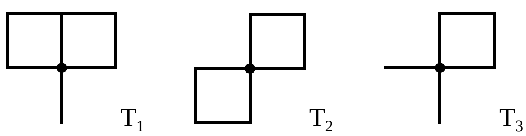
Idealized cell constants: monoclinic, C2/m, a = 14.1Å, b = 13.7Å, c = 7.4Å, β = 102.4°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	19	33	56	81	105	136	175	219	4·5·4·6·5·6
T_2 (8, 1)	4	10	22	37	54	79	108	140	176	215	4·4·5·8·6·6
T_3 (8, 1)	4	11	21	35	57	80	106	139	176	218	4·5·5·6·6·8

Secondary building units: 5-3 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *RUB-3[1,2]

References:

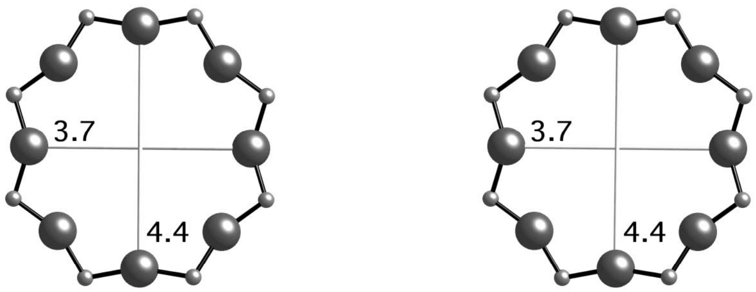
(1) Marler, B., Grünewald-Lüke, A. and Gies, H. *Zeolites*, **15**, 388-399 (1995)

(2) Marler, B., Grünewald-Lüke, A. and Gies, H. *Microporous and Mesoporous Materials*, **26**, 49-59 (1998)

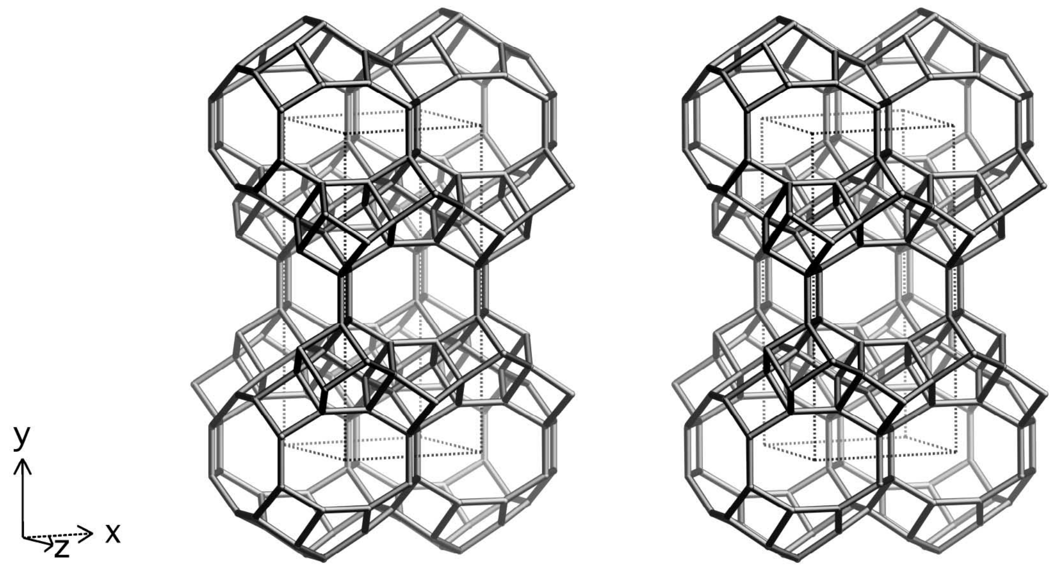
Crystal chemical data: |$(C_8H_{15}N)_2$| **[**$Si_{24}O_{48}$**]-RTE**
$C_8H_{15}N$ = exo-2-aminobicyclo[2.2.1.]heptane
monoclinic, C12/m1
a = 14.039Å, b = 13.602Å, c = 7.428Å, β = 102.22° [(1)]

Framework density: 17.3 T/1000Å^3

Channels: [001] **8** 3.7 x 4.4*



8-ring viewed along [001]



framework viewed along [001]

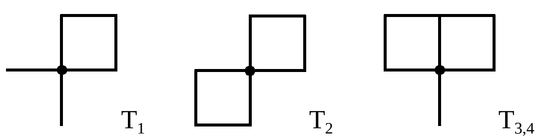
Idealized cell constants: monoclinic, C2/m, a = 9.8Å, b = 20.5Å, c = 10.0Å, β = 96.9°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	21	34	53	78	108	137	165	207	4·6·5·6·5·8
T_2 (8, 1)	4	10	21	36	54	75	100	136	181	214	4·4·5·8·5·8
T_3 (8, 1)	4	10	19	31	50	82	106	130	168	203	4·5·4·6·5·5
T_4 (8, 1)	4	10	18	31	55	77	103	134	165	214	4·5·4·8·5·5

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *RUB-13[1]

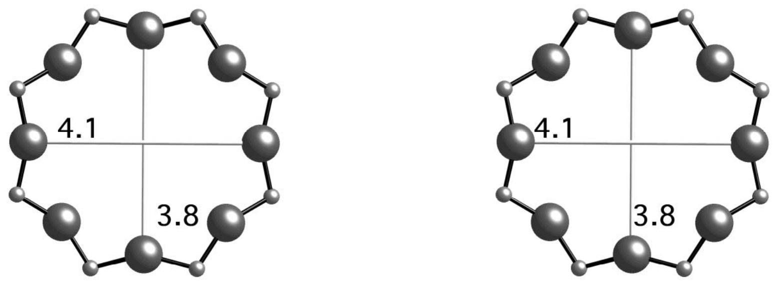
References:

(1) Vortmann, S., Marler, B., Gies, H. and Daniels, P. *Microporous Materials*, **4**, 111-121 (1995)

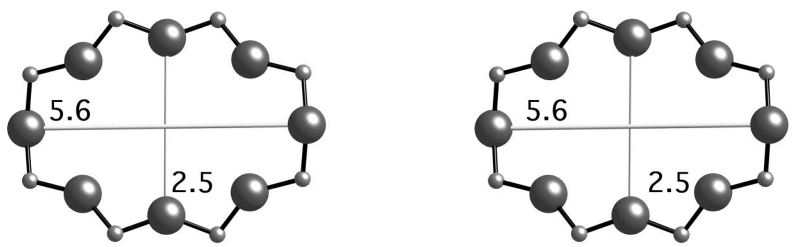
Crystal chemical data: |$(C_{10}H_{21}N^+)_2$| **[**$B_2Si_{30}O_{64}$**]-RTH**
$C_{10}H_{21}N^+$ = pentamethylpiperidinium
monoclinic, C12/m1, a = 9.659Å, b = 20.461Å, c = 9.831Å, β = 96.58° (1)

Framework density: 16.6 T/1000Å^3

Channels: [100] **8** 3.8 x 4.1* ↔ [001] **8** 2.5 x 5.6*

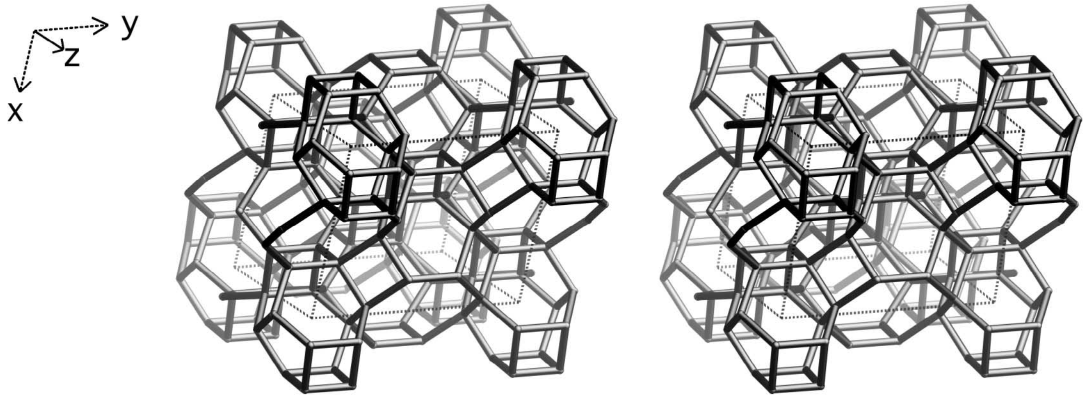


8-ring viewed along [100]



8-ring viewed along [001]

RUT Framework Type C2/m



framework viewed along [001]

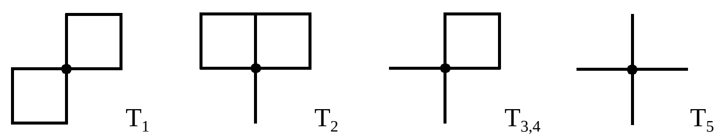
Idealized cell constants: monoclinic, C2/m, a = 13.2Å, b = 13.3Å, c = 12.5Å, β = 114.8°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	21	37	58	87	116	146	185	232	4·4·5·6·5·8
T_2 (8, 1)	4	10	21	38	60	84	113	148	192	232	4·5·4·6·5·6
T_3 (8, 1)	4	11	23	38	58	86	114	148	189	234	4·5·5·6·6·6
T_4 (8, 1)	4	11	21	37	62	85	114	148	185	232	4·5·5·5·6·8
T_5 (4, 2)	4	12	22	40	58	82	116	154	186	232	5·5·6·6·6·6

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures:

*RUB-10[1]
|TMA-|**[**Si-O**]-RUT**[2]
B-NU-1[3]
Fe-NU-1[3]
Ga-NU-1[3]
NU-1[4]

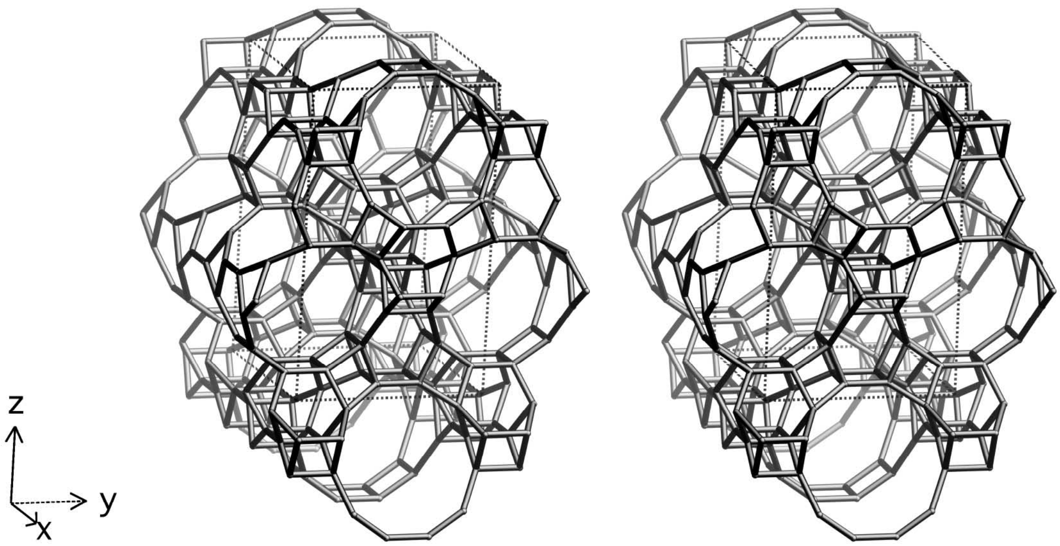
References:

(1) Gies, H. and Rius, J. *Z. Kristallogr.*, **210**, 475-480 (1995)
(2) Broach, R.W., McGuire, N.K., Chao, C.C. and Kirchner, R.M. *J. Phys. Chem. Solids*, **56**, 1363-1368 (1995)
(3) Bellussi, G., Millini, R., Carati, A., Maddinelli, G. and Gervasini, A. *Zeolites*, **10**, 642-649 (1990)
(4) Whittam, T.V. and Youll, B. *U.S. Patent 4,060,590*, (1977)

Crystal chemical data: |$(C_4H_{12}N^+)_4$| [$B_4Si_{32}O_{72}$]-**RUT**
$C_4H_{12}N^+$ = tetramethylamonium
monoclinic, $P12_1/a1$
a = 13.112Å, b = 12.903Å, c = 12.407Å, β = 113.50° (1)

Framework density: 18.7 T/1000Å^3

Channels: apertures formed by 6-rings only



framework viewed along [100]

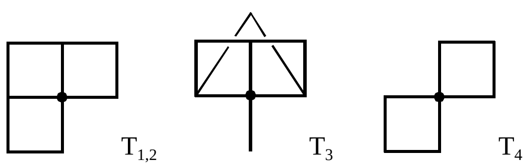
Idealized cell constants: tetragonal, I$\bar{4}$m2, a = 13.4Å, c = 21.9Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	16	25	39	61	84	102	124	158	$4\cdot4\cdot4\cdot6_2\cdot6_3\cdot12_4$
T_2 (16, 1)	4	9	17	27	40	61	85	106	132	167	$4\cdot4\cdot4\cdot12_5\cdot6\cdot6_3$
T_3 (16, 1)	4	9	16	25	39	58	79	104	130	158	$4\cdot6\cdot4\cdot6\cdot4\cdot12_6$
T_4 (8, 2)	4	10	16	25	42	61	82	108	132	156	$4\cdot4\cdot6\cdot6\cdot6_2\cdot12_5$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *STA-1[1]

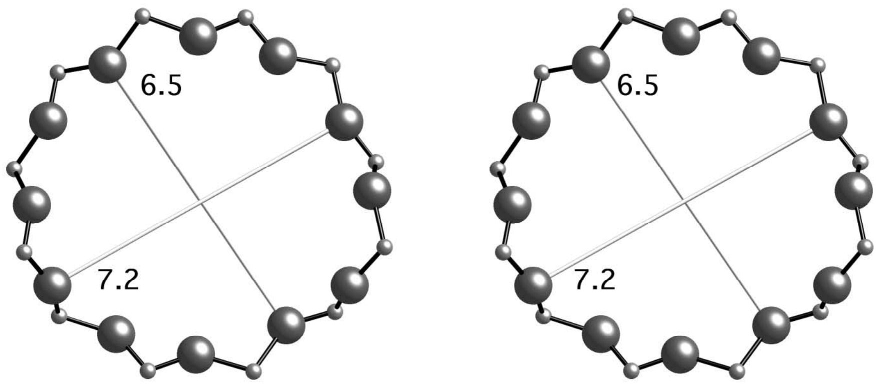
References:

(1) Noble, G.W., Wright, P.A., Lightfoot, P., Morris, R.E., Hudson, K.J., Kvick, Å. and Graafsma, H. *Angew. Chem., Int. Ed.*, **36**, 81-83 (1997)

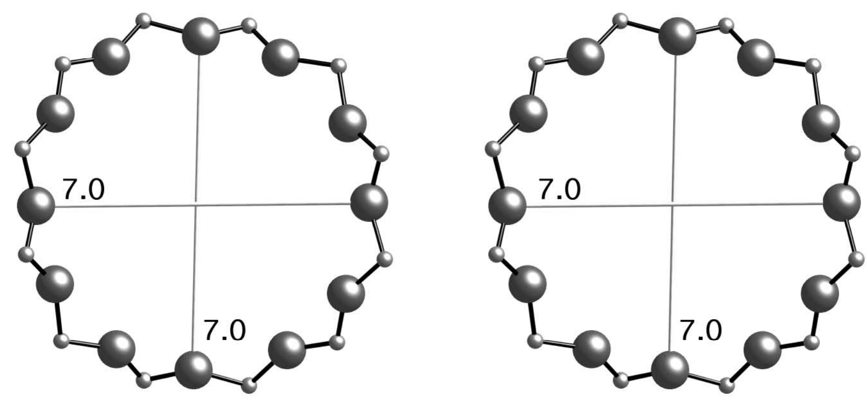
Crystal chemical data: |$(C_{21}H_{40}N_2^{2+})_{2.6}$ $(H_2O)_6$| **[**$Mg_5Al_{23}P_{28}$ O_{112}**]-SAO**
$C_{21}H_{40}N_2^{2+}$ = $C_7H_{13}N$ - $(CH_2)_7$ - $C_7H_{13}N$
$C_7H_{13}N$ = quinuclidine
tetragonal, P$\bar{4}$n2, a = 13.810Å, c = 21.969Å [(1)]

Framework density: 13.4 T/1000Å^3

Channels: <100>**12** 6.5 x 7.2** ↔ [001] **12** 7.0 x 7.0*

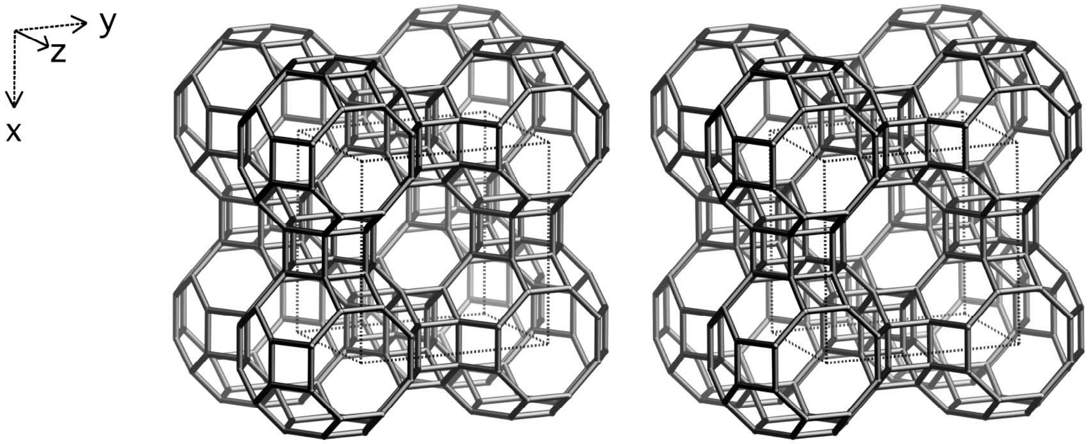


12-ring viewed along <100>



12-ring viewed along [001]

SAS Framework Type I4/mmm



framework viewed along [001]

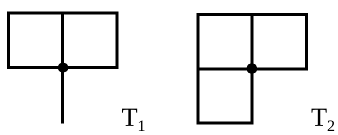
Idealized cell constants: tetragonal, I4/mmm, a = 14.3Å, c = 10.4Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	10	19	30	45	65	90	118	145	175	4·6·4·6·6·8
T_2 (16, 2)	4	9	17	30	48	68	87	109	142	184	4·4·4·6·6·6

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures: *STA-6[1]

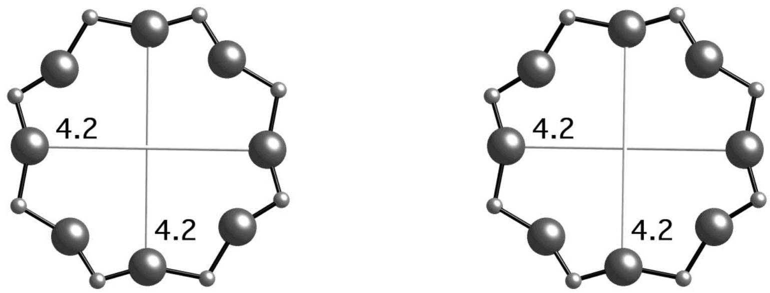
References:

(1) Patinec, V., Wright, P.A., Lightfoot, P., Aitken, R.A. and Cox, P.A. *J. Chem. Soc., Dalton Trans.*, 3909-3911 (1999)

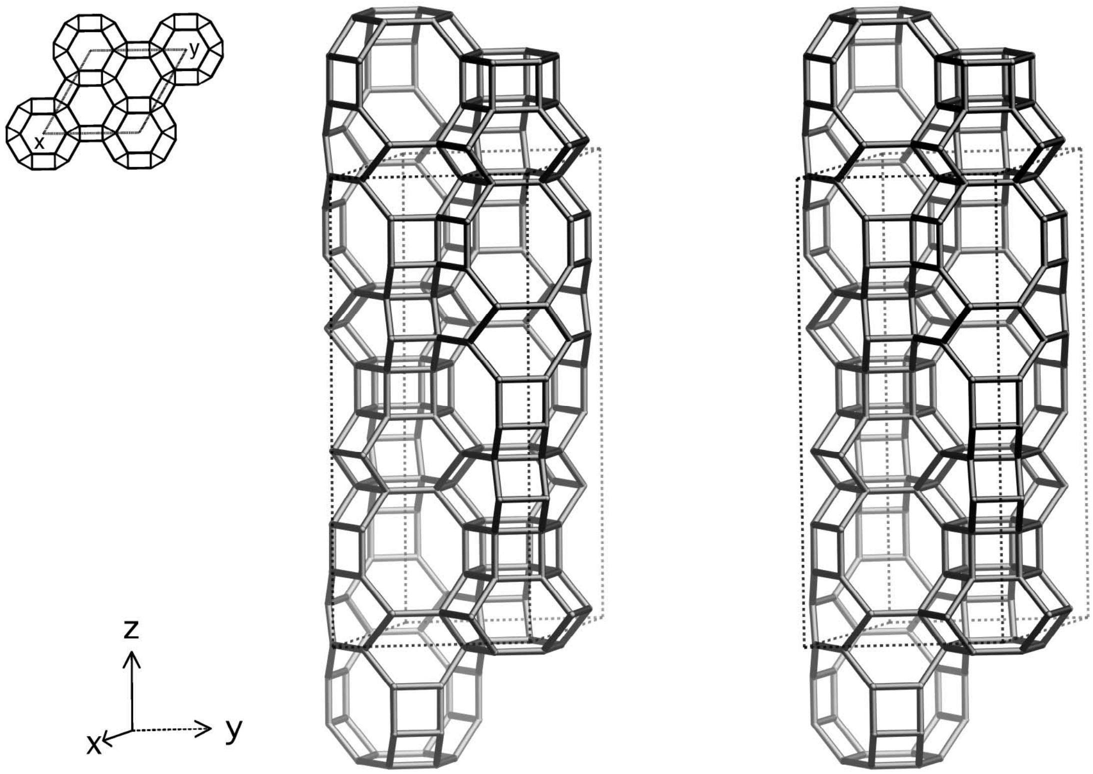
Crystal chemical data: |$(C_{14}H_{34}N_4^{2+})_{1.5}$ $(H_2O)_{2.5}$| **[**$Mg_3Al_{13}P_{16}$ O_{64}**]-SAS**
$C_{14}H_{32}N_4$ = 1,4,8,11-tetramethyl-1,4,8,11-tetraazatetradecane
tetragonal, P4/mnc, a = 14.282Å, c = 10.249Å [(1)]

Framework density: 15.3 T/1000Å^3

Channels: [001] **8** 4.2 x 4.2*



8-ring viewed along [001]



framework viewed normal to [001] (top left: projection down [001])

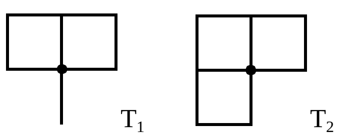
Idealized cell constants: trigonal, $R\bar{3}m$, a = 12.9Å, c = 30.6Å

Coordination sequences and vertex symbols:

T_1 (36, 1)	4	10	20	33	50	71	95	124	158	197	4·6·4·8·6·6
T_2 (36, 1)	4	9	17	30	50	75	100	126	157	194	4·4·4·6·6·8

Secondary building units: 6

Loop configuration of T-Atoms:



Framework description: ABBCBCCACAAB sequence of 6-rings

Isotypic framework structures: *STA-2[1]

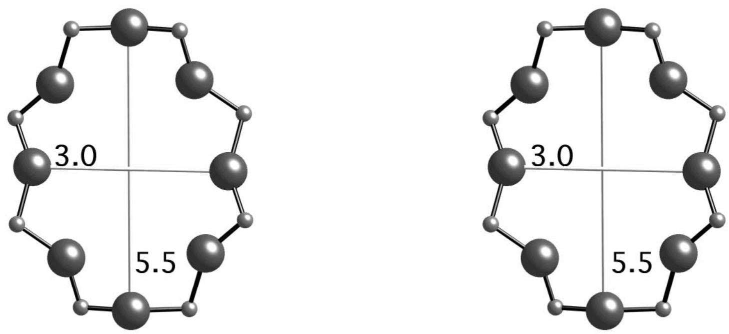
References:

(1) Noble, G.W., Wright, P.A. and Kvick, Å. *J. Chem. Soc., Dalton Trans.*, 4485-4490 (1997)

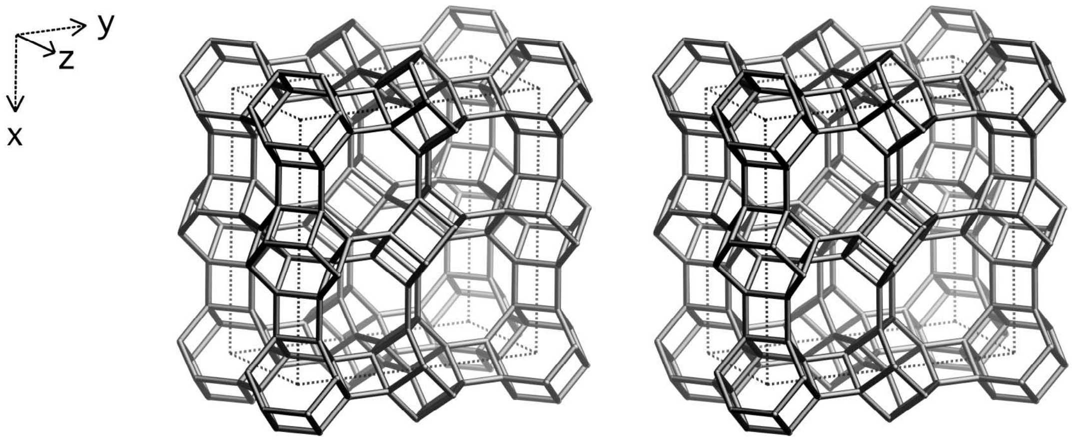
Crystal chemical data: $|(C_{18}H_{34}N_2^{2+})_3\ (H_2O)_{22.5}|$ **[**$Mg_{5.4}Al_{30.6}P_{36}\ O_{144}$**]-SAT**
$C_{18}H_{34}N_2^{2+} = C_7H_{13}N - (CH_2)_4 - C_7H_{13}N$
$C_7H_{13}N$ = quinuclidine
trigonal, $R\bar{3}$, a = 12.726 Å, c = 30.939Å [(1)]

Framework density: 16.6 T/1000Å^3

Channels: ⊥ [001] 3.0 x 5.5***



8-ring viewed normal to [001]



framework viewed along [001]

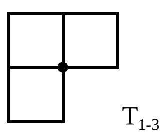
Idealized cell constants: tetragonal, P4/nmm (origin choice 2), a = 18.7Å, c = 9.4Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	17	29	45	65	88	113	143	179	4·4·4·8·6·8
T_2 (16, 1)	4	9	17	29	45	65	88	114	144	177	4·4·4·8·6·8
T_3 (16, 1)	4	9	17	29	45	63	84	112	144	177	4·4·4·8·6·8

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*Mg-STA-7[1]
Co-STA-7[1]
Zn-STA-7[1]

References:

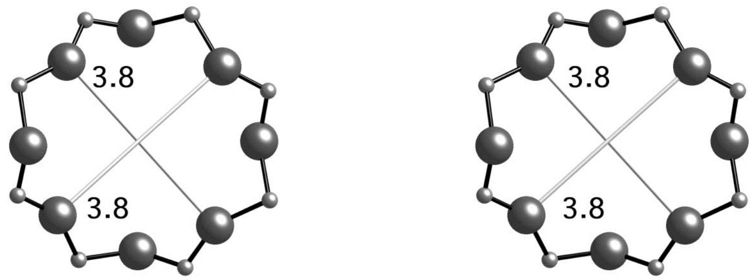
(1) Wright, P.A., Maple, M.J., Slawin, A.M.Z., Patinec, V., Aitken, R.A., Welsh, S. and Cox, P.A. *J. Chem. Soc., Dalton Trans.*, 1243-1248 (2000)

Mg-STA-7 **Type Material** **SAV**

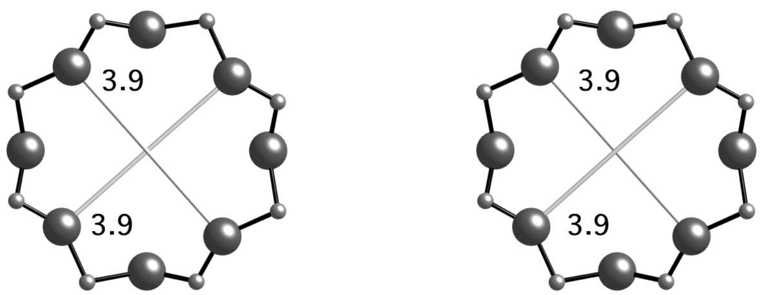
Crystal chemical data: **|**$(C_{18}H_{42}N_6)_{1.96}$ $(H_2O)_7$**|** **[**$Mg_{4.8}Al_{19.2}P_{24}$ O_{96}**]-SAV**
$C_{18}H_{42}N_6$ = 1,4,7,10,13,16-hexamethyl-1,4,7,10,13,16-hexaazacyclooctadecane
tetragonal, P4/n, a = 18.773Å, c = 9.454Å [(1)]

Framework density: 14.4 T/1000Å^3

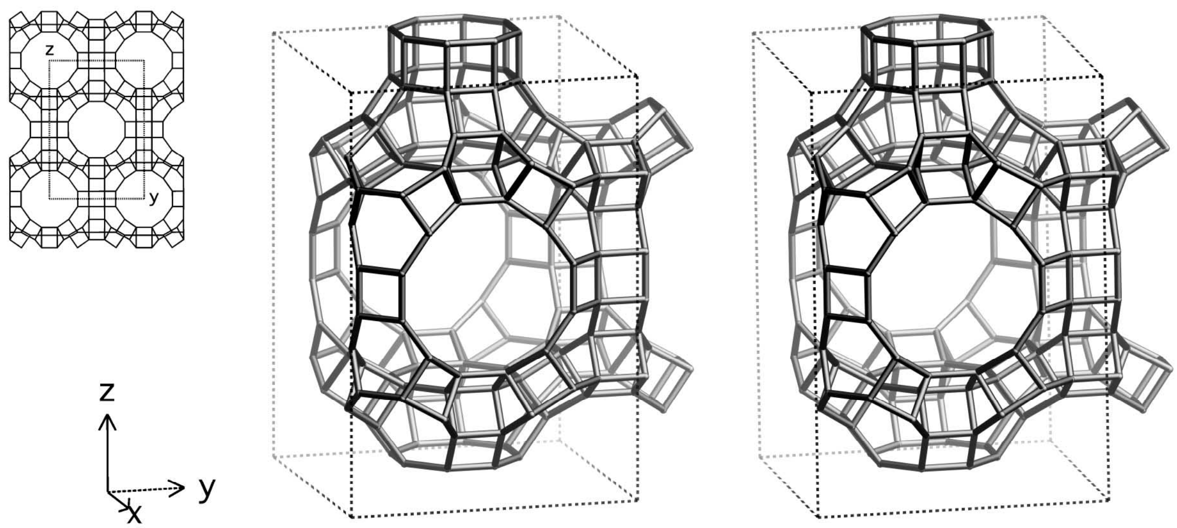
Channels: <100> **8** 3.8 x 3.8** ↔ [001] **8** 3.9 x 3.9*



8-ring viewed along <100>



8-ring viewed along [001]



framework viewed along [100] (top left: projection down [100])

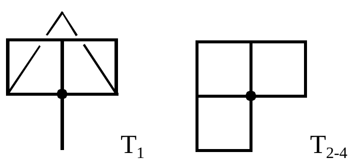
Idealized cell constants: tetragonal, I4/mmm, a = 18.5Å, c = 27.1Å

Coordination sequences and vertex symbols:

T_1 (32, 1)	4	9	17	27	38	55	78	102	129	157	$4{\cdot}6{\cdot}4{\cdot}8{\cdot}4{\cdot}8_7$
T_2 (32, 1)	4	9	17	28	41	57	77	101	130	162	$4{\cdot}4{\cdot}4{\cdot}6{\cdot}8{\cdot}12$
T_3 (32, 1)	4	9	17	27	39	56	77	100	126	157	$4{\cdot}4{\cdot}4{\cdot}8{\cdot}6{\cdot}6_2$
T_4 (32, 1)	4	9	17	27	40	59	79	99	126	158	$4{\cdot}4{\cdot}4{\cdot}8_2{\cdot}6_2{\cdot}8_4$

Secondary building units: 8-8 or 8 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*UCSB-8Co(1)
UCSB-8Mg(1)
UCSB-8Mn(1)
UCSB-8Zn(1)

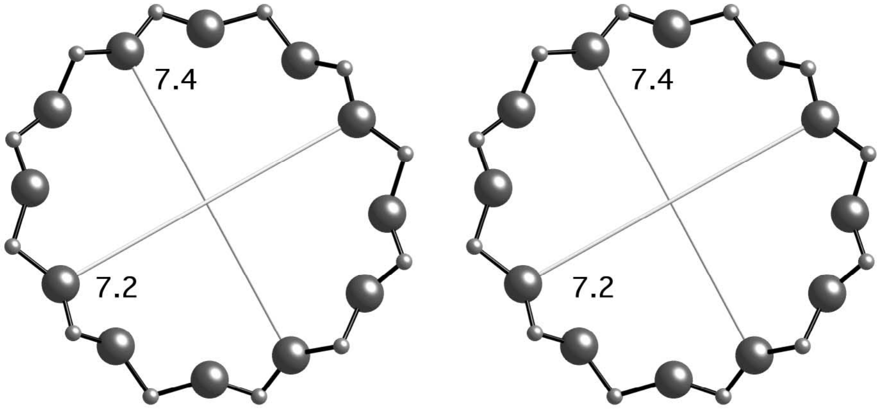
References:

(1) Bu, X.H., Feng, P.Y. and Stucky, G.D. *Science*, **278**, 2080-2085 (1997)

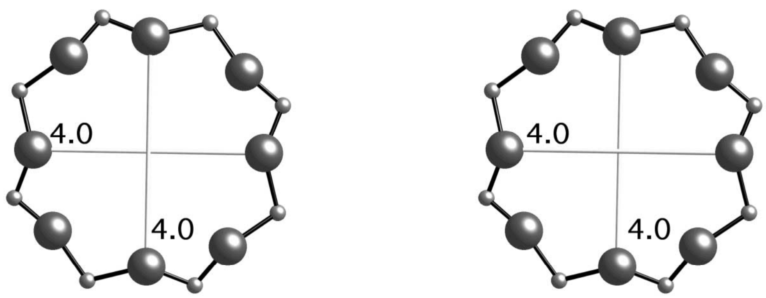
Crystal chemical data: $|(C_9H_{24}N_2^{2+})_{16}|$ $[Al_{32}Co_{32}P_{64}O_{256}]$**-SBE**
$C_9H_{22}N_2$ = 1,9-diaminononane
tetragonal, P4/nnc, a = 19.065Å, c = 27.594 Å [(1)]

Framework density: 12.8 T/1000Å^3

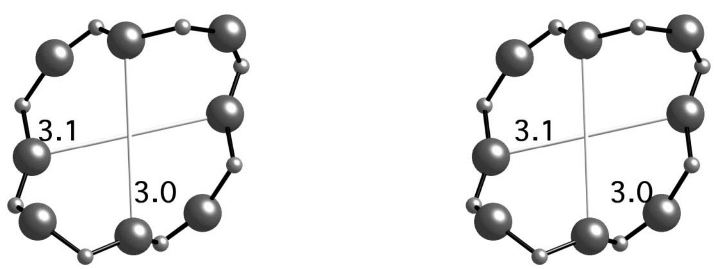
Channels: <100> **12** 7.2 x 7.4** ↔ [001] **8** 4.0 x 4.0*



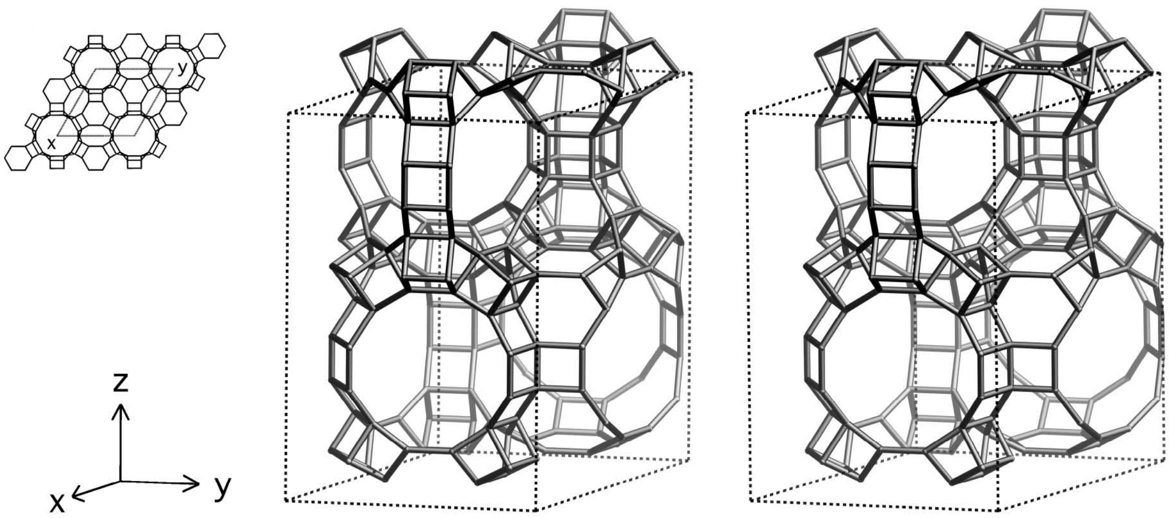
12-ring viewed along <100>



8-ring viewed along [001] and



second 8-ring along [001]



framework viewed normal to [001] (top left: projection down [001])

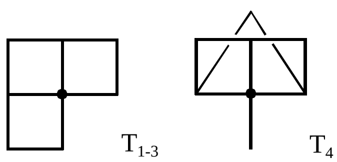
Idealized cell constants: hexagonal, $P6_3/mmc$, a = 17.2Å, c = 27.3Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	9	17	28	41	56	75	100	127	157	$4·4·4·12_6·6_2·8_4$
T_2 (24, 1)	4	9	17	27	39	55	75	100	127	156	$4·4·4·8·6·6_2$
T_3 (24, 1)	4	9	16	25	38	58	84	111	135	157	4·4·4·6·6·12
T_4 (24, 1)	4	9	16	24	35	53	77	104	130	153	$4·6·4·6·4·8_7$

Secondary building units: 4

Loop configuration of T-Atoms:



Isotypic framework structures:

*UCSB-6GaCo[1]
UCSB-6Co[1]
UCSB-6GaMg[1]
UCSB-6GaZn[1]
UCSB-6Mg[1]
UCSB-6Mn[1]
UCSB-6Zn[1]

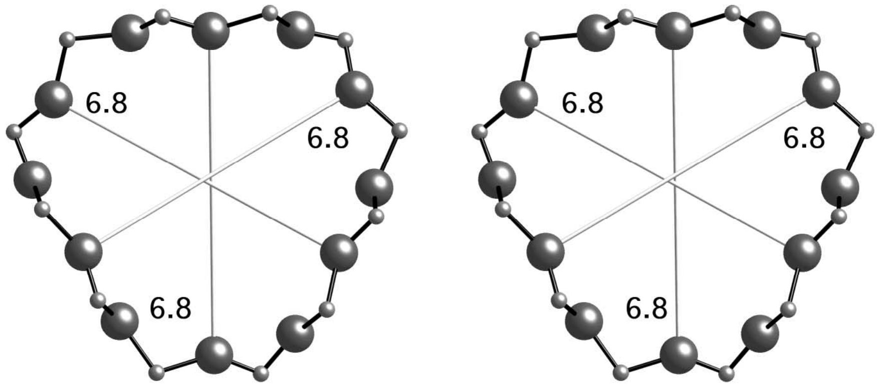
References:

(1) Bu, X.H., Feng, P.Y. and Stucky, G.D. *Science*, **278**, 2080-2085 (1997)

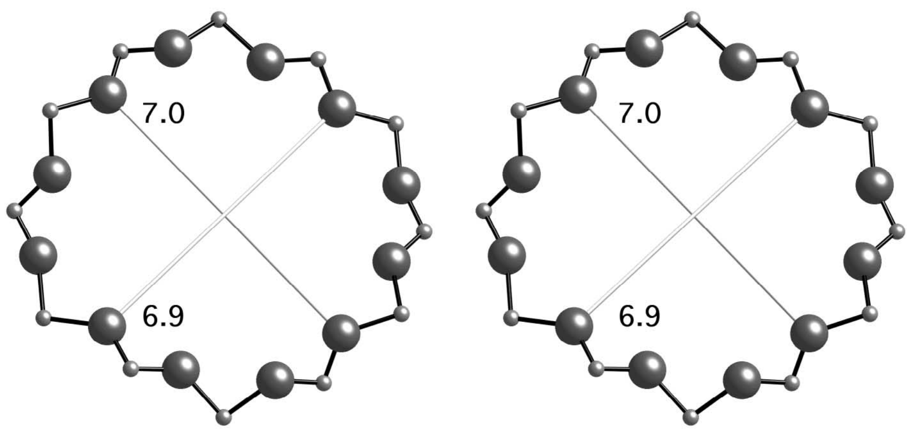
Crystal chemical data: **|**$(C_9H_{24}N_2)^{2+}{}_{12}$**|** **[**$Ga_{24}Co_{24}P_{48}O_{192}$**]-SBS**
$C_9H_{22}N_2$ = 1,9-diaminononane
trigonal, P$\bar{3}$1c, a = 17.836Å, c = 27.182Å [(1)]

Framework density: 12.8 T/1000Å^3

Channels: [001] **12** 6.8 x 6.8* ↔ ⊥ [001] **12** 6.9 x 7.0**

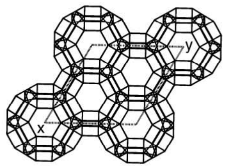


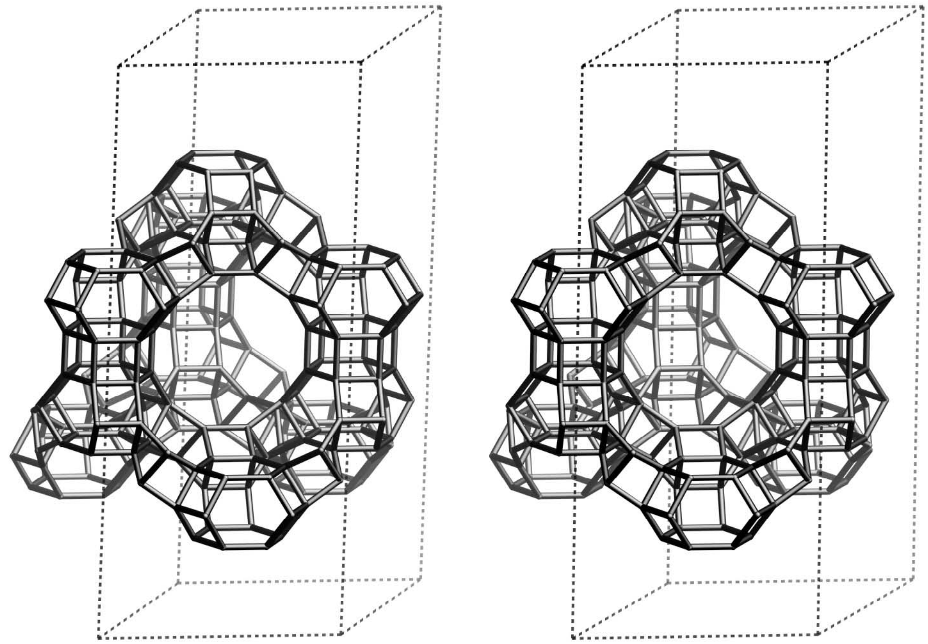
12-ring viewed along [001]

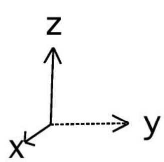


12-ring viewed normal to [001]

See Appendix A for 8-ring along [001]







framework viewed normal to [001] (top left: projection down [001])

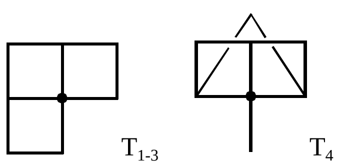
Idealized cell constants: trigonal, $R\bar{3}m$, a = 17.2Å, c = 41.0Å

Coordination sequences and vertex symbols:

T_1 (36, 1)	4	9	16	25	38	58	84	111	135	157	4·4·4·6·6·12
T_2 (36, 1)	4	9	17	28	41	56	75	100	127	157	$4\cdot4\cdot4\cdot12_6\cdot6_2\cdot8_4$
T_3 (36, 1)	4	9	17	27	39	55	75	100	127	156	$4\cdot4\cdot4\cdot8\cdot6\cdot6_2$
T_4 (36, 1)	4	9	16	24	35	53	77	104	130	153	$4\cdot6\cdot4\cdot6\cdot4\cdot8_7$

Secondary building units: 6 or 4-2

Loop configuration of T-Atoms:



Isotypic framework structures:
*UCSB-10GaZn[1]
UCSB-10Co[1]
UCSB-10Mg[1]
UCSB-10Zn[1]

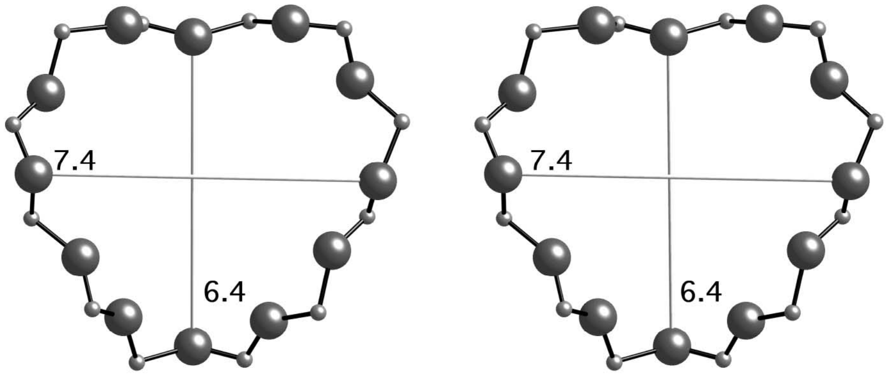
References:

(1) Bu, X.H., Feng, P.Y. and Stucky, G.D. *Science*, **278**, 2080-2085 (1997)

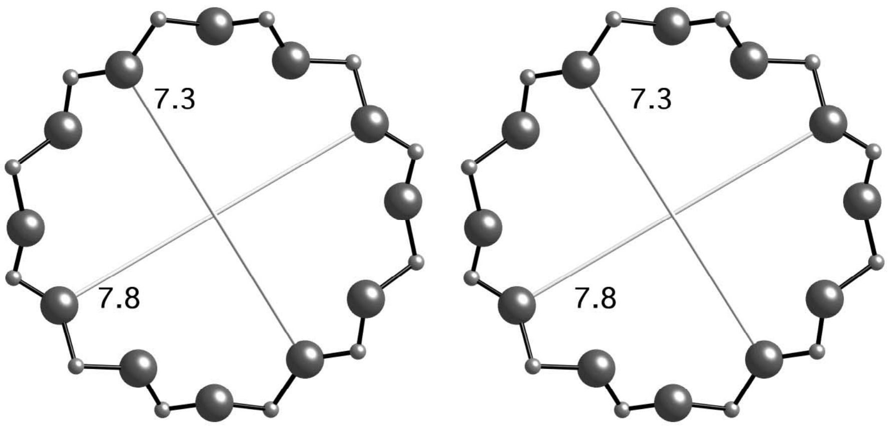
Crystal chemical data: |$(C_{10}H_{26}N_2O_3^{2+})_{18}$| [$Ga_{36}Zn_{36}P_{72}O_{288}$]**-SBT**
$C_{10}H_{24}N_2O_3$ = 4,7,10-trioxa-1,13-tridecanediamine
trigonal, $R\bar{3}$, a = 18.080Å, c = 41.951Å [(1)]

Framework density: 12.1 T/1000Å^3

Channels: [001] **12** 6.4 x 7.4 * ↔ ⊥[001] **12** 7.3 x 7.8**



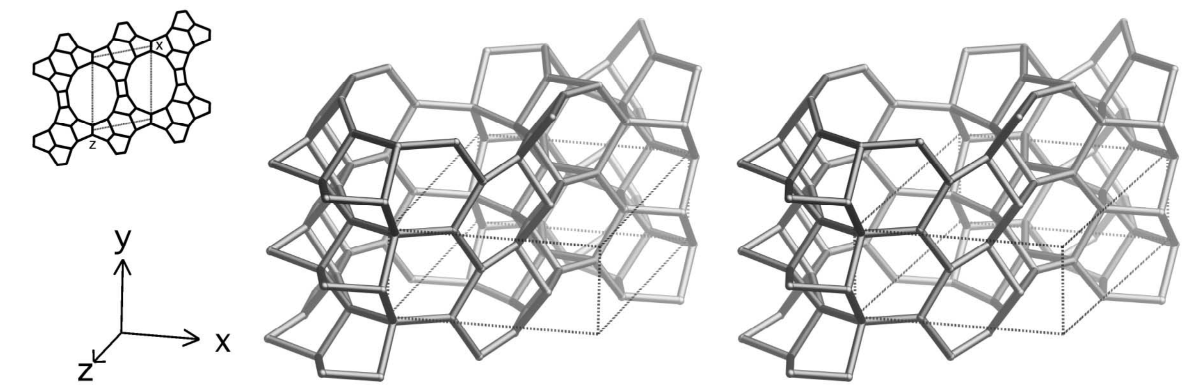
12-ring viewed along [001]



12-ring viewed normal to [001]

See Appendix A for 8-ring viewed along [102]

SFE Framework Type $P12_11$



framework viewed normal to [010] (top left: projection down [010])

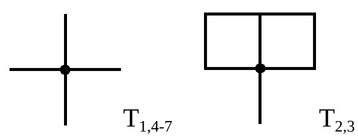
Idealized cell constants: monoclinic, $P12_11$, a = 11.4Å, b = 5.1Å, c = 13.9Å, β = 100.9°

Coordination sequences and vertex symbols:

T_1 (2, 1)	4	12	20	37	62	82	114	142	192	238	5·5·5·5·6·12
T_2 (2, 1)	4	10	19	35	58	86	108	144	183	233	4·5·4·5·6·12
T_3 (2, 1)	4	10	20	35	57	83	116	141	181	230	4·5·4·5·12·*
T_4 (2, 1)	4	12	22	36	56	86	114	150	179	232	5·5·5·5·6·*
T_5 (2, 1)	4	12	22	37	55	83	120	149	177	227	5·6·6·6·6·6
T_6 (2, 1)	4	12	24	37	54	80	117	158	184	219	5·6·6·6·6·6
T_7 (2, 1)	4	12	23	41	58	78	111	154	198	235	5·5·5·5·6·12

Secondary building units: 5-2

Loop configuration of T-Atoms:



Isotypic framework structures: *SSZ-48[1]

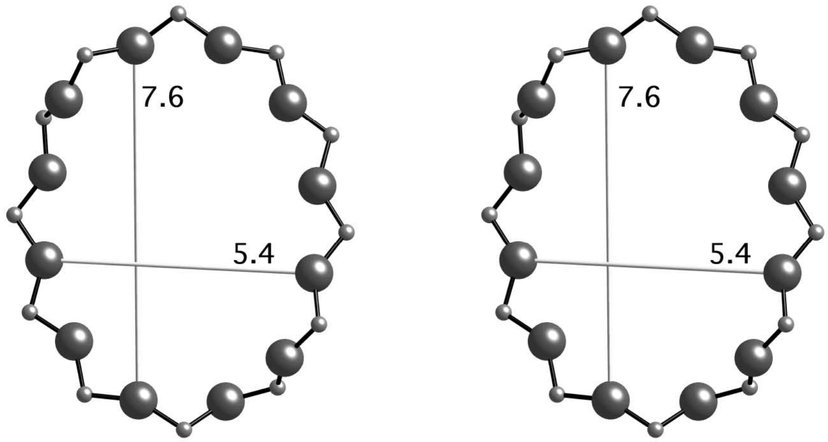
References:

(1) Wagner, P., Terasaki, O., Ritsch, S., Nery, J.G., Zones, S.I., Davis, M.E. and Hiraga, K. *J. Phys. Chem. B*, **103**, 8245-8250 (1999)

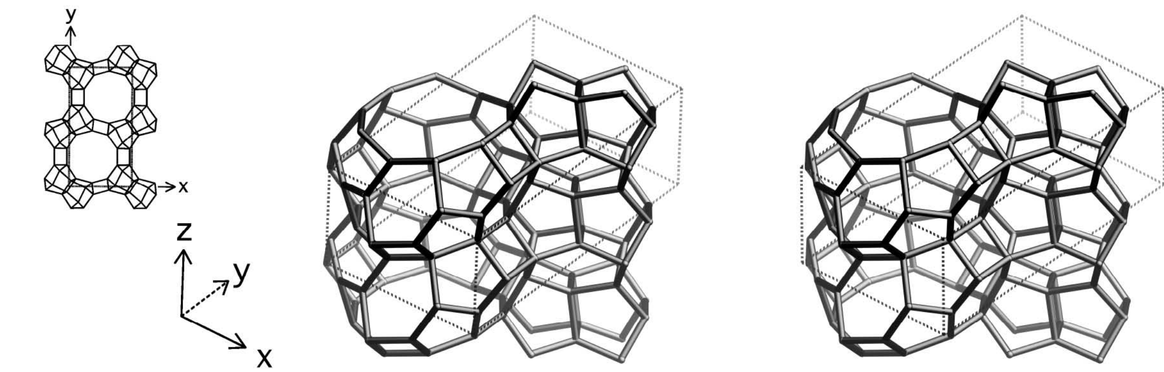
Crystal chemical data: **[**Si_{14} O_{28}**]-SFE**
monoclinic, P12_11
a = 11.153Å, b = 5.002Å, c = 13.667Å, β = 100.63° (1)

Framework density: 18.7 T/1000Å^3

Channels: [010] **12** 5.4 x 7.6*



12-ring viewed along [010]



framework viewed normal to [001] (top left: projection down [001])

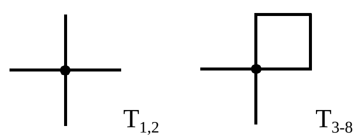
Idealized cell constants: monoclinic, $P2_1/m$, a = 11.5Å, b = 21.7Å, c = 7.2Å, β = 93.2°

Coordination sequences and vertex symbols:

T_1 (4, 1)	4	12	20	34	56	87	115	143	176	224	$5\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_2 (4, 1)	4	12	20	34	56	88	115	142	177	225	$5\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_3 (4, 1)	4	11	22	38	57	80	111	148	189	228	$4\cdot5\cdot5\cdot6\cdot5\cdot10$
T_4 (4, 1)	4	11	22	39	54	84	110	145	189	234	$4\cdot5\cdot5\cdot6\cdot5\cdot10$
T_5 (4, 1)	4	11	23	37	57	82	113	150	184	228	$4\cdot5\cdot5\cdot6\cdot5\cdot10$
T_6 (4, 1)	4	11	20	31	58	86	115	142	174	225	$4\cdot6_2\cdot5\cdot5\cdot5\cdot5$
T_7 (4, 1)	4	11	19	36	55	82	113	148	181	220	$4\cdot6\cdot5\cdot5\cdot5\cdot5$
T_8 (4, 1)	4	11	23	36	59	79	114	147	183	229	$4\cdot5\cdot5\cdot6\cdot5\cdot10$

Secondary building units: 5-3

Loop configuration of T-Atoms:



Isotypic framework structures: *SSZ-44[1]

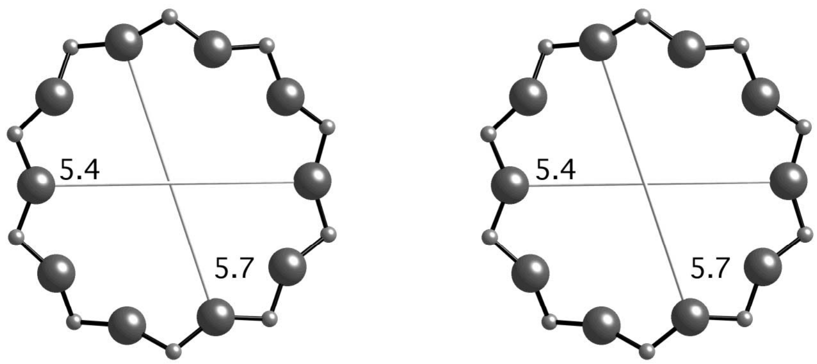
References:

(1) Wagner, P., Zones, S.I., Davis, M.E. and Medrud, R.C. *Angew. Chem., Int. Ed.*, **38**, 1269-1272 (1999)

Crystal chemical data: **[**Si_{32} O_{64}**]-SFF**
monoclinic, $P2_1/m$, a = 11.485 Å, b = 21.946Å, c = 7.388Å, β = 94.70° [(1)]

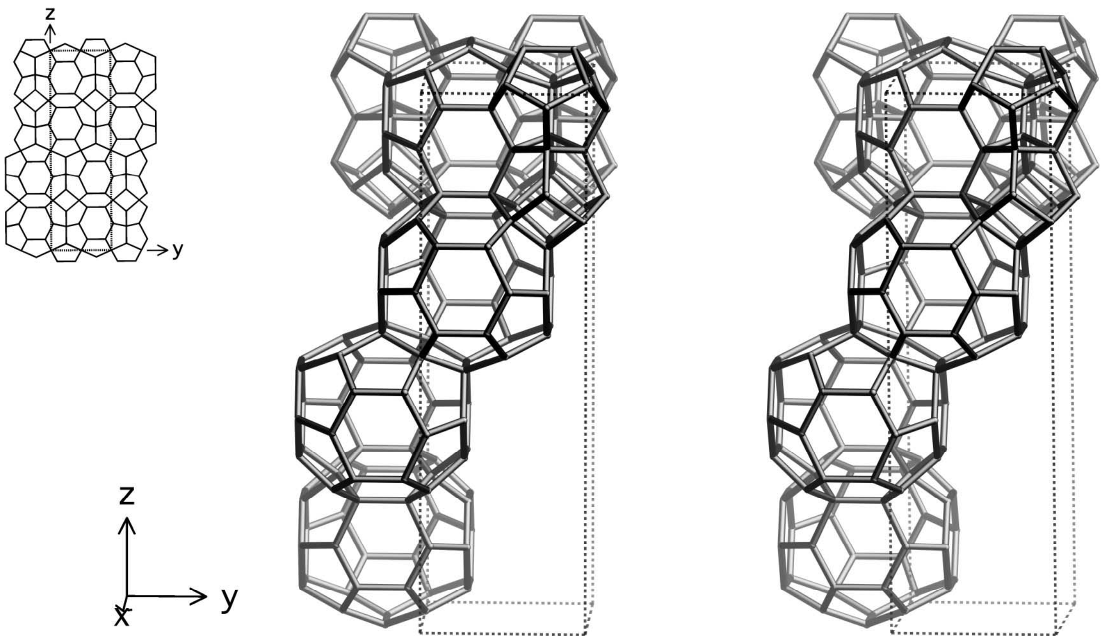
Framework density: 17.2 T/1000Å^3

Channels: [001] **10** 5.4 x 5.7*



10-ring viewed along [001]

SGT Framework Type $I4_1/amd$



framework viewed along [100] (top left: projection down [100])

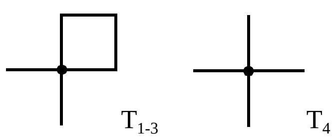
Idealized cell constants: tetragonal, $I4_1$/amd (origin choice 2), a = 10.3Å, c = 34.4Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	11	22	37	62	89	120	155	202	257	4·6·5·5·5·5
T_2 (16, m)	4	11	21	37	63	86	121	152	196	258	4·6·5·5·5·5
T_3 (16, 2)	4	11	23	38	62	92	113	159	210	244	4·6·5·5·5·5
T_4 (16, m)	4	12	24	42	61	87	128	168	205	250	5·6·5·6·5·6

Secondary building units: 5-3

Loop configuration of T-Atoms:



Isotypic framework structures: *Sigma-2[1]

References:

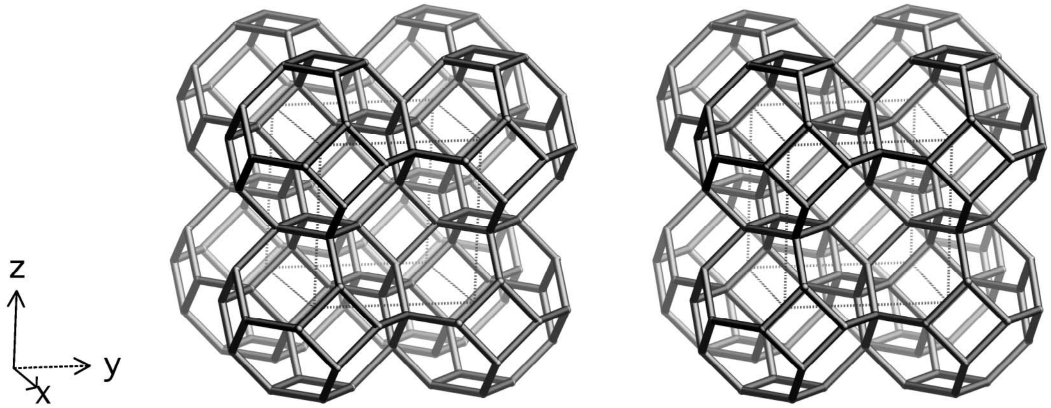
(1) McCusker, L.B. *J. Appl. Crystallogr.*, **21**, 305-310 (1988)

Crystal chemical data: **|**$(C_{10}H_{17}N)_4$**|** **[**Si_{64} O_{128}**]-SGT**
$C_{10}H_{17}N$ = 1-aminoadamantane
tetragonal, $I4_1/amd$, a = 10.239Å, c = 34.383Å [(1)]

Framework density: 17.8 T/1000Å^3

Channels: apertures formed by 6-rings only

SOD Framework Type Im$\bar{3}$m



framework viewed along [100]

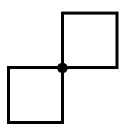
Idealized cell constants: cubic, Im$\bar{3}$m, a = 9.0Å

Coordination sequences and vertex symbols:

T_1 (12, $\bar{4}$2m)	4 10 20 34 52 74 100 130 164 202	4·4·6·6·6·6

Secondary building units: 6-2 or 6 or 4

Loop configuration of T-Atoms:



Framework description: ABC sequence of 6-rings

Isotypic framework structures:

*Sodalite[1,2]
[Al-Co-P-O]-SOD[3]
[Al-Ge-O]-SOD[4]
[Be-As-O]-SOD[5]
[Be-P-O]-SOD[5]
[Be-Si-O]-SOD[6]
[Co-Ga-P-O]-SOD[7]
[Ga-Co-P-O]-SOD[3]
[Ga-Ge-O]-SOD[4]
[Ga-Si-O]-SOD[8]
[Zn-As-O]-SOD[9]
[Zn-Ga-As-O]-SOD[7]
[Zn-Ga-P-O]-SOD[7]
[Zn-P-O]-SOD[9]
|Ca_8 $(WO_4)_2$|[$Al_{12}O_{24}$]-SOD[10]
AlPO-20 plus numerous compositional variants[11,12]
Basic sodalite[13,14]
Bicchulite[15]
Danalite[16]
G[17]
Genthelvite[18]
Hauyn[19]
Helvin[20]
Hydroxo sodalite[21]
Nosean[22]
Silica sodalite[23]
TMA sodalite[24]
Tugtupite[25,26]

Crystal chemical data: $|Na^{+}_{8}\ Cl^{-}_{2}|$ **[**$Al_6Si_6\ O_{24}$**]-SOD**
cubic, $P\bar{4}3n$, a = 8.870Å [(2)]

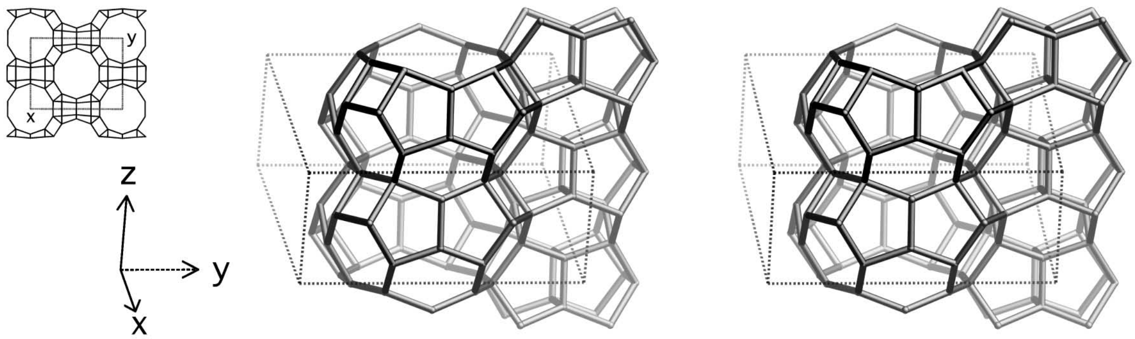
Framework density: 17.2 T/1000$Å^3$

Channels: apertures formed by 6-rings only

References:

(1) Pauling, L. *Z. Kristallogr.*, **74**, 213-225 (1930)
(2) Loens, J. and Schulz, H. *Acta Crystallogr.*, **23**, 434-436 (1967)
(3) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(4) Bu, X., Feng, P., Gier, T.E., Zhao, D. and Stucky, G.D. *J. Am. Chem. Soc.*, **120**, 13389-13397 (1998)
(5) Gier, T.E., Harrison, W.T.A. and Stucky, G.D. *Angew. Chem.*, *Int. Ed.*, **30**, 1169-1171 (1991)
(6) Dann, S.E. and Weller, M.T. *Inorg. Chem.*, **35**, 555-558 (1996)
(7) Bu, X., Gier, T.E., Feng, P. and Stucky, G.D. *Microporous and Mesoporous Materials*, **20**, 371-379 (1998)
(8) McCusker, L.B., Meier, W.M., Suzuki, K. and Shin, S. *Zeolites*, **6**, 388-391 (1986)
(9) Nenoff, T.M., Harrison, W.T.A., Gier, T.E. and Stucky, G.D. *J. Am. Chem. Soc.*, **113**, 378-379 (1991)
(10) Depmeier, W. *Acta Crystallogr.*, **C40**, 226-231 (1984)
(11) Wilson, S.T., Lok, B.M., Messina, C.A., Cannan, T.R. and Flanigen, E.M. *J. Am. Chem. Soc.*, **104**, 1146-1147 (1982)
(12) Flanigen, E.M., Lok, B.M., Patton, R.L. and Wilson, S.T. In *Proc. 7th Int. Zeolite Conf.*, (eds. Y. Murakami, A. Iijima and J.W. Ward), pp. 103-112 (1986), Kodansha, Tokyo
(13) Barrer, R.M. and White, E.A.D. *J. Chem. Soc.*, 1267-1278 (1951)
(14) Hassan, I. and Grundy, H.D. *Acta Crystallogr.*, **C39**, 3-5 (1983)
(15) Sahl, K. and Chatterjee, N.D. *Z. Kristallogr.*, **146**, 35-41 (1977)
(16) Glass, J.J., Jahns, R.H. and Stevens, R.E. *Am. Mineral.*, **29**, 163-191 (1944)
(17) Shishakova, T.N. and Dubinin, M.M. *Izv. Akad. Nauk SSSR*, 1303- (1965)
(18) Merlino, S. In *Feldspars and Feldspathoids*, (ed. W.L. Brown), pp. 435-470 (1983), Reidel, Dordrecht
(19) Loehn, J. and Schulz, H. *N. Jb. Miner. Abh.*, **109**, 201-210 (1968)
(20) Glass, J.J., Jahns, R.H. and Stevens, R.E. *Am. Mineral.*, **29**, 163-191 (1944)
(21) Felsche, J., Luger, S. and Baerlocher, Ch. *Zeolites*, **6**, 367-372 (1986)
(22) Schulz, H. and Saalfeld, H. *Tschermaks Min. Petr. Mitt.*, **10**, 225-232 (1965)
(23) Bibby, D.M. and Dale, M.P. *Nature*, **317**, 157-158 (1985)
(24) Baerlocher, Ch. and Meier, W.M. *Helv. Chim. Acta*, **52**, 1853-1860 (1969)
(25) Sorensen, H. *Am. Mineral.*, **48**, 1178 (1963)
(26) Hassan, I. and Grundy, H.D. *Can. Mineral.*, **29**, 385-390 (1991)

STF Framework Type C2/m



framework viewed normal to [001] (top left: projection down [001])

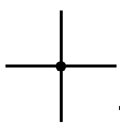
Idealized cell constants: monoclinic, C2/m, a = 14.1Å, b = 18.2Å, c = 7.5Å, β = 99.0°

Coordination sequences and vertex symbols:

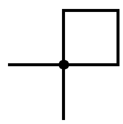
T_1 (8, 1)	4	12	20	34	56	88	114	143	173	224	$5\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_2 (8, 1)	4	11	22	39	55	82	111	149	188	223	$4\cdot5\cdot5\cdot6\cdot5\cdot10$
T_3 (8, 1)	4	11	23	36	59	80	113	147	183	227	$4\cdot5\cdot5\cdot6\cdot5\cdot10$
T_4 (4, m)	4	11	19	36	54	84	110	146	179	226	$4\cdot6\cdot5\cdot5\cdot5\cdot5$
T_5 (4, m)	4	11	20	31	58	84	117	137	174	229	$4\cdot6_2\cdot5\cdot5\cdot5\cdot5$

Secondary building units: 5-3

Loop configuration of T-Atoms:



T_1



$T_{2\text{-}5}$

Isotypic framework structures: *SSZ-35[1]
ITQ-9[2]

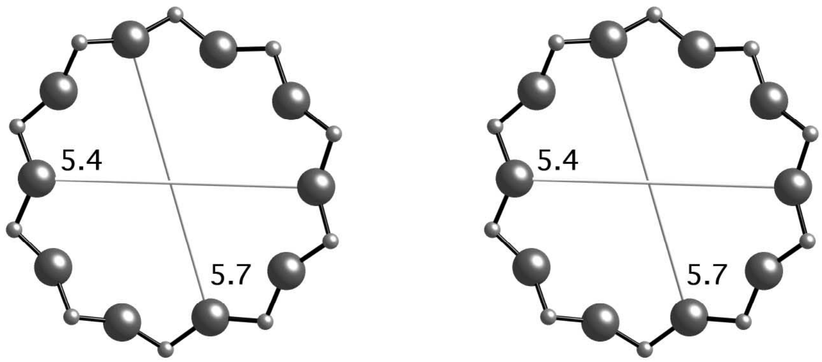
References:

(1) Wagner, P., Zones, S.I., Davis, M.E. and Medrud, R.C. *Angew. Chem., Int. Ed.*, **38**, 1269-1272 (1999)
(2) Villaescusa, L.A., Barrett, P.A. and Camblor, M.A. *Chem. Commun.*, **21**, 2329-2330 (1998)

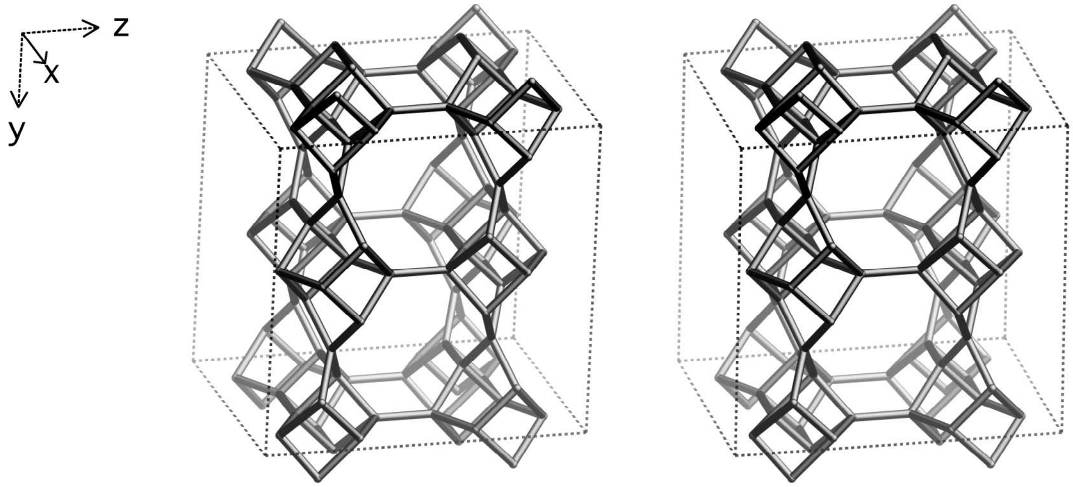
Crystal chemical data: **[**Si_{16} O_{32}**]-STF**
triclinic, $P\bar{1}$, a = 11.411Å, b = 11.527Å, c = 7.377Å
α = 94.66°, β = 96.21°, γ = 104.89° [(1)]
(Relationship to unit cell of Framework Type: V' = V/2)

Framework density: 17.3 T/1000Å^3

Channels: [001] **10** 5.4 x 5.7*



10-ring viewed along [001]



framework viewed along [100]

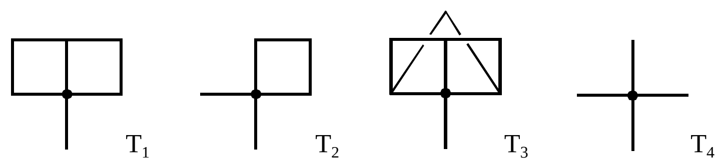
Idealized cell constants: orthorhombic, Fmmm, a = 13.5Å, b = 17.8Å, c = 17.9Å

Coordination sequences and vertex symbols:

T_1 (32, 1)	4	10	20	34	57	82	103	138	181	220	$4\cdot5\cdot4\cdot6\cdot5\cdot6_2$
T_2 (16, m)	4	11	20	36	57	78	109	140	176	222	$4\cdot8\cdot5\cdot8_2\cdot5\cdot8_2$
T_3 (16, m)	4	9	17	35	57	77	103	138	188	225	$4\cdot5\cdot4\cdot5\cdot4\cdot8$
T_4 (8, 222)	4	12	18	34	58	82	112	130	172	228	$5_2\cdot5_2\cdot6\cdot6\cdot10\cdot10$

Secondary building units: 4-4=1

Loop configuration of T-Atoms:



Isotypic framework structures:

*Stilbite(1-3)
Barrerite(4)
Stellerite(5)
Synthetic barrerite(6)
Synthetic stellerite(6)
Synthetic stilbite(7)

Alternate designation:

Desmine (discredited)
Epidesmin (obsolete)

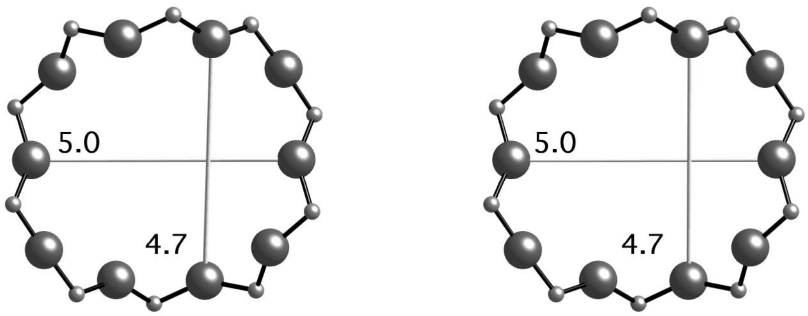
References:

(1) Galli, E. and Gottardi, G. *Miner. Petrogr. Acta*, **12**, 1-10 (1966)
(2) Slaughter, M. *Am. Mineral.*, **55**, 387-397 (1970)

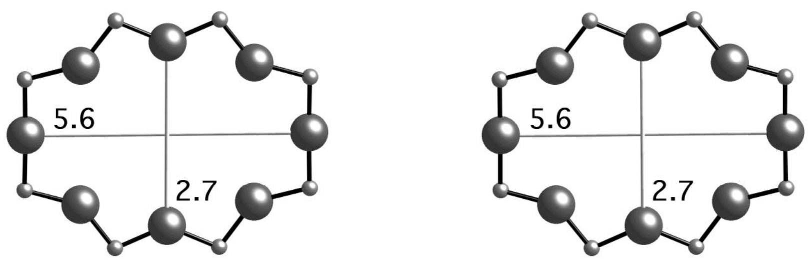
Crystal chemical data: $|Na^{+}_{4}Ca^{2+}_{8} (H_2O)_{56}|$ **[**$Al_{20}Si_{52} O_{144}$**]-STI**
monoclinic, C12/m1, a = 13.64Å, b = 18.24Å, c = 11.27Å, β = 128.0° [(3)]
(Relationship to unit cell of Framework Type:
a' = a, b' = b , c' = c/2sin(β)
or, as vectors, **a'** = **a**, **b'** = **b**, **c'** = (**c** - **a**)/2)

Framework density: 16.3 T/1000Å^3

Channels: [100] **10** 4.7 x 5.0* ↔ [001] **8** 2.7 x 5.6*



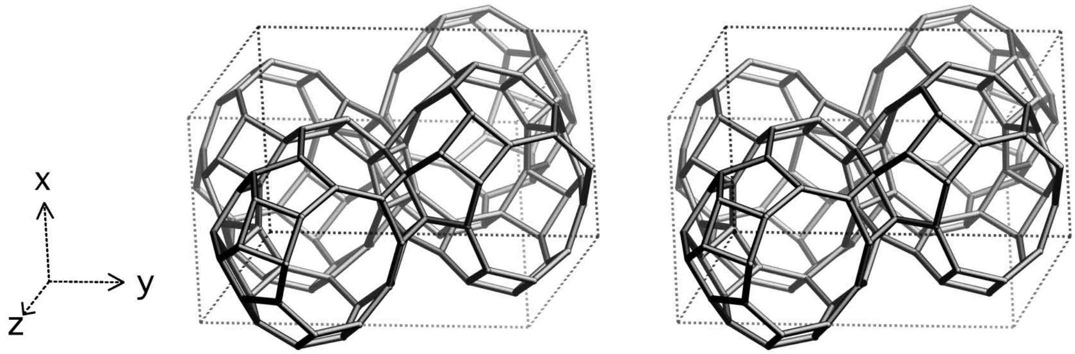
10-ring viewed along [100]



8-ring along [001]

References (cont.):

(3) Galli, E. *Acta Crystallogr.*, **B27**, 833-841 (1971)
(4) Galli, E. and Alberti, A. *Bull. Soc. fr. Minéral. Cristallogr.*, **98**, 331-340 (1975)
(5) Galli, E. and Alberti, A. *Bull. Soc. fr. Minéral. Cristallogr.*, **98**, 11-18 (1975)
(6) Ghobarkar, H., Schaef, O. and Guth, U. *J. Solid State Chem.*, **142**, 451-454 (1999)
(7) Ghobarkar, H. and Schaef, O. *J. Phys. D: Appl. Phys.*, **31**, 3172-3176 (1998)



framework viewed normal to [100]

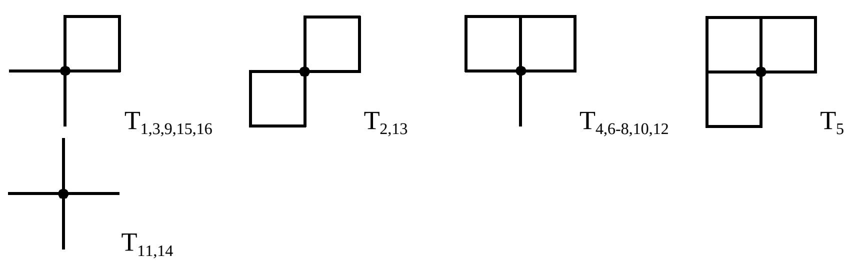
Idealized cell constants: monoclinic, $P12_1/n1$, a = 13.1Å, b = 21.9Å, c = 13.6Å, β = 102.9°

Coordination sequences and vertex symbols:

T_1 (4, 1)	4	11	22	36	55	84	111	142	179	233	4·5·5·7·6·9
T_2 (4, 1)	4	10	23	37	57	78	108	146	187	225	4·4·5·9·6·7
T_3 (4, 1)	4	11	20	35	54	84	108	142	178	225	4·6·5·6·5·7
T_4 (4, 1)	4	10	19	32	55	81	109	141	174	223	4·5·4·6·5·5
T_5 (4, 1)	4	9	21	38	57	78	104	144	195	220	4·4·4·9·5·7
T_6 (4, 1)	4	10	20	40	57	78	105	143	191	226	4·5·4·7·5·9
T_7 (4, 1)	4	10	20	35	57	77	108	139	184	230	4·6·4·6·5·7
T_8 (4, 1)	4	10	19	35	54	77	108	146	174	215	4·5·4·9·5·6
T_9 (4, 1)	4	11	19	34	53	81	115	140	173	219	4·6·5·5·5·5
T_{10} (4, 1)	4	10	21	31	51	83	115	134	172	216	4·6·4·6·5·5
T_{11} (4, 1)	4	12	20	31	50	88	117	137	167	221	$5·5_2·5·6·6·6$
T_{12} (4, 1)	4	10	18	35	59	77	107	150	179	221	4·5·4·9·5·5
T_{13} (4, 1)	4	10	20	38	55	75	104	149	185	218	4·4·5·6·5·9
T_{14} (4, 1)	4	12	21	33	58	86	112	141	174	226	5·5·5·6·5·7
T_{15} (4, 1)	4	11	21	33	55	78	111	145	175	217	4·5·5·6·5·9
T_{16} (4, 1)	4	11	20	32	54	89	115	138	172	221	4·6·5·5·5·5

Secondary building units: 5-1

Loop configuration of T-Atoms:

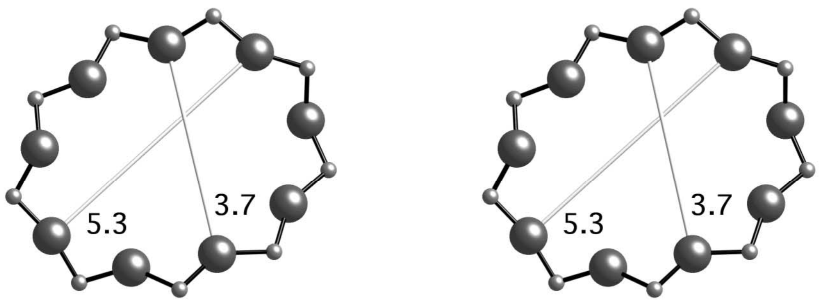


Isotypic framework structures: *SSZ-23[1]

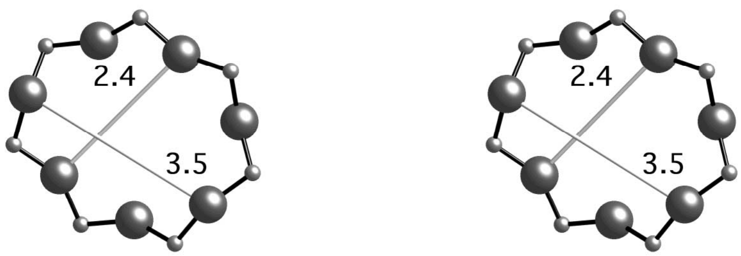
Crystal chemical data: $|(C_{13}H_{24}N^{+})_{4.1}\ F^{-}_{3.3}(OH)^{-}_{0.8}|$**[**$Si_{64}\ O_{128}$**]-STT**
$C_{13}H_{24}N^{+}$ = N,N,N-trimethyl-1-adamantammonium
monoclinic, $P12_1/n1$
a = 12.959Å, b = 21.792Å, c = 13.598Å, β = 101.85° [(1)]

Framework density: 17.0 T/1000Å^3

Channels: [101] **9** 3.7 x 5.3* ↔ [001] **7** 2.4 x 3.5*



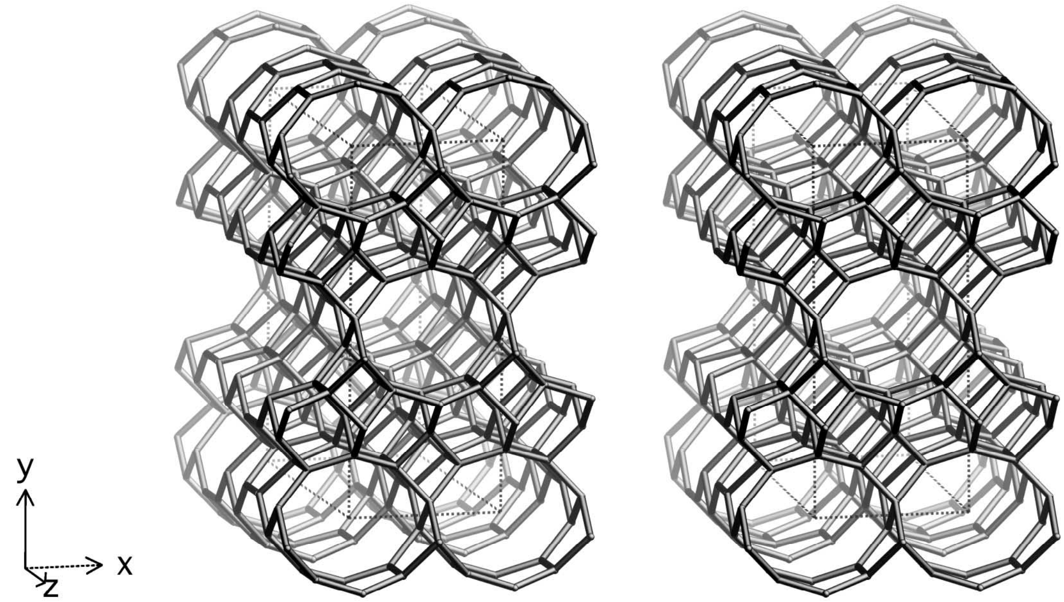
9-ring viewed along [101]



7-ring viewed along [001]

References:

(1) Camblor, M.A., Díaz-Cabañas, M.-J., Pérez-Pariente, J., Teat, S.J., Clegg, W., Shannon, I.J., Lightfoot, P., Wright, P.A. and Morris, R.E. *Angew. Chem., Int. Ed.*, **37**, 2122-2126 (1998)



framework viewed along [001]

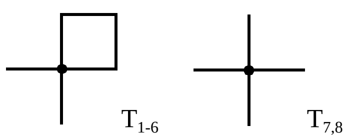
Idealized cell constants: orthorhombic, Cmcm, a = 9.8Å, b = 23.6Å, c = 20.2Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	19	35	57	83	113	137	184	231	$4\cdot5\cdot5\cdot6\cdot5\cdot6_2$
T_2 (16, 1)	4	11	21	35	58	87	103	144	188	227	$4\cdot5\cdot5\cdot6_2\cdot5\cdot10_3$
T_3 (8, m)	4	11	22	39	62	82	104	142	178	225	$4\cdot10_6\cdot5\cdot6_3\cdot5\cdot6_3$
T_4 (8, m)	4	11	21	41	61	77	107	134	186	232	$4\cdot5_2\cdot5\cdot10_4\cdot5\cdot10_4$
T_5 (8, m)	4	11	19	34	56	78	116	152	184	208	$4\cdot5_2\cdot5\cdot6\cdot5\cdot6$
T_6 (8, m)	4	11	21	33	53	80	112	155	187	214	$4\cdot10_2\cdot5\cdot6_3\cdot5\cdot6_3$
T_7 (8, m)	4	12	20	35	55	81	119	142	182	216	$5\cdot6\cdot5\cdot6\cdot5_2\cdot10_2$
T_8 (8, m)	4	12	23	32	49	86	124	147	167	219	$5\cdot6_2\cdot5\cdot6_2\cdot10\cdot10_4$

Secondary building units: 2-6-2

Loop configuration of T-Atoms:



Isotypic framework structures: *Terranovaite[1]

References:

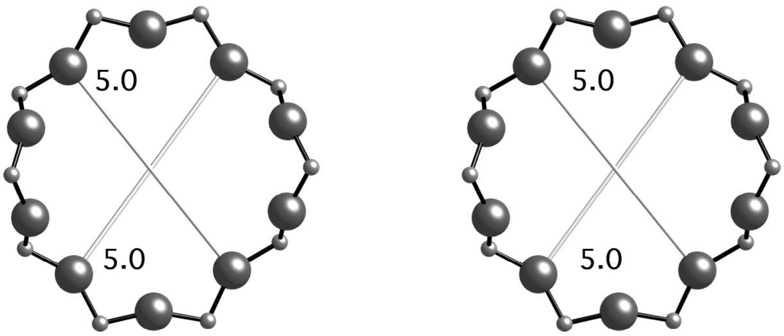
(1) Galli, E., Quartieri, S., Vezzalini, G., Alberti, A. and Franzini, M. *Am. Mineral.*, **82**, 423-429 (1997)

Terranovaite Type Material TER

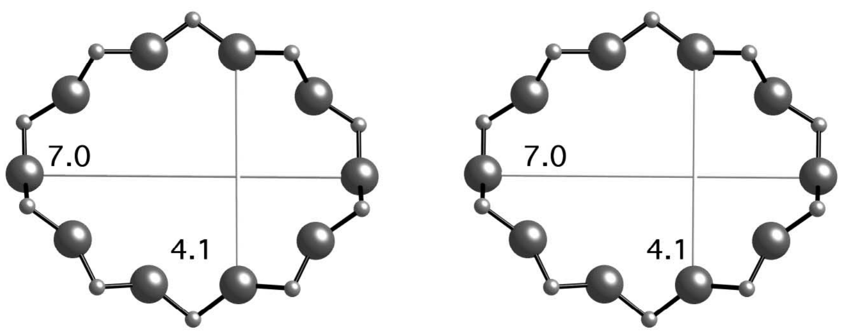
Crystal chemical data: $|Na^{+}_{4.2}K^{+}_{0.2}Mg^{2+}_{0.2}Ca^{2+}_{3.7}(H_2O)_{29}|$ **[**$Al_{12.3}Si_{67.7}O_{160}$**]-TER**
orthorhombic, Cmcm, a = 9.747Å, b = 23.880Å, c = 20.068Å (1)

Framework density: 17.1 T/1000Å^3

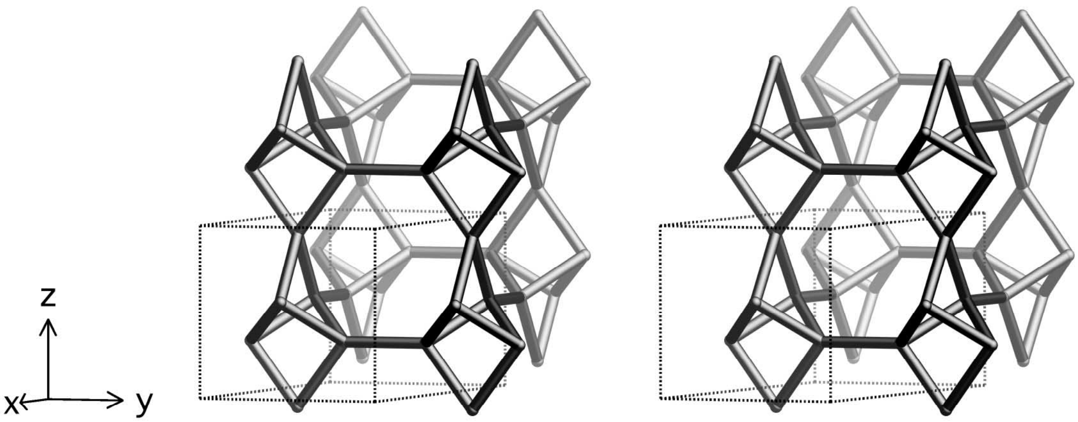
Channels: [100] **10** 5.0 x 5.0* ↔ [001] **10** 4.1 x 7.0*



10-ring viewed along [100]



10-ring viewed along [001]



framework viewed normal to [001]

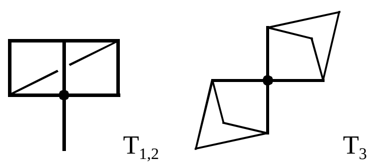
Idealized cell constants: orthorhombic, Pmma, a = 14.0Å, b = 7.0Å, c = 6.5Å

Coordination sequences and vertex symbols:

T_1 (4, m)	4	9	19	35	52	72	100	131	163	201	$4 \cdot 8_3 \cdot 4 \cdot 8_3 \cdot 4_2 \cdot 8_4$
T_2 (4, m)	4	9	19	33	50	74	100	129	165	201	$4 \cdot 8_3 \cdot 4 \cdot 8_3 \cdot 4_2 \cdot 8_4$
T_3 (2, mm2)	4	8	18	34	50	68	100	130	160	204	$4_2 \cdot 4_2 \cdot 8_4 \cdot 8_4 \cdot 8_4 \cdot 8_4$

Secondary building units: 4=1

Loop configuration of T-Atoms:



Isotypic framework structures:
*Thomsonite[1-3]
[Al-Co-P-O**]-THO**[4]
[Ga-Co-P-O**]-THO**[4]
Na-V[5]
Synthetic thomsonite[6]

References:

(1) Taylor, W.H., Meek, C.A. and Jackson, W.W. *Z. Kristallogr.*, **84**, 373-398 (1933)
(2) Alberti, A., Vezzalini, G. and Tazzoli, V. *Zeolites*, **1**, 91-97 (1981)
(3) Pluth, J.J., Smith, J.V. and Kvick, A. *Zeolites*, **5**, 74-80 (1985)
(4) Feng, P.Y., Bu, X.H. and Stucky, G.D. *Nature*, **388**, 735-741 (1997)
(5) Barrer, R.M., Baynham, J.W., Bultitude, F.W. and Meier, W.M. *J. Chem. Soc.*, 195-208 (1959)
(6) Ghobarkar, H. and Schaef, O. *Cryst. Res. Technol.*, **32**, 653-657 (1997)

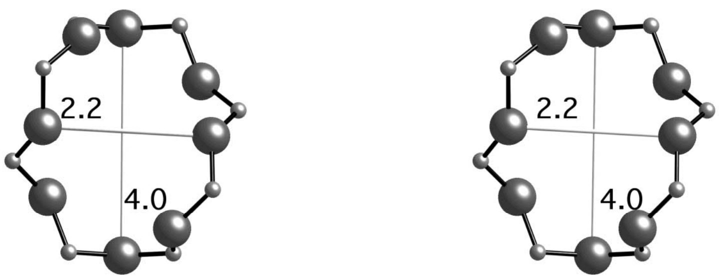
Crystal chemical data: |$Na^{+}_{4}Ca^{2+}_{8}$ $(H_2O)_{24}$| [$Al_{20}Si_{20}$ O_{80}]-**THO**
orthorhombic, Pncn, a = 13.088Å, b = 13.052Å, c = 13.229Å [(3)]
(Relationship to unit cell of Framework Type: a' = a, b' = 2b, c' = 2c)

Framework density: 17.7 T/1000Å^3

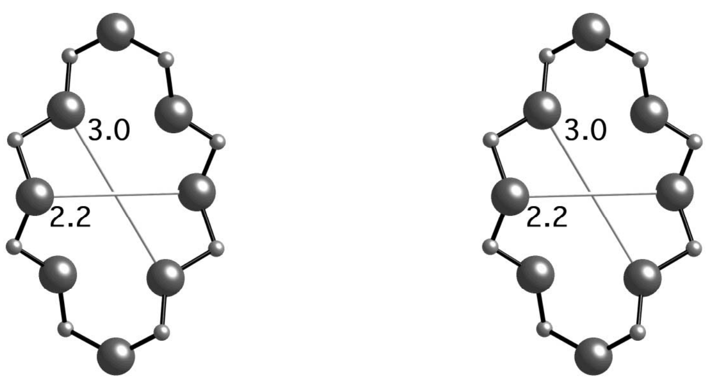
Channels: [100] **8** 2.3 x 3.9* ↔ [010] **8** 2.2 x 4.0* ↔ [001]**8** 2.2 x 3.0* (variable due to considerable flexibility of framework)



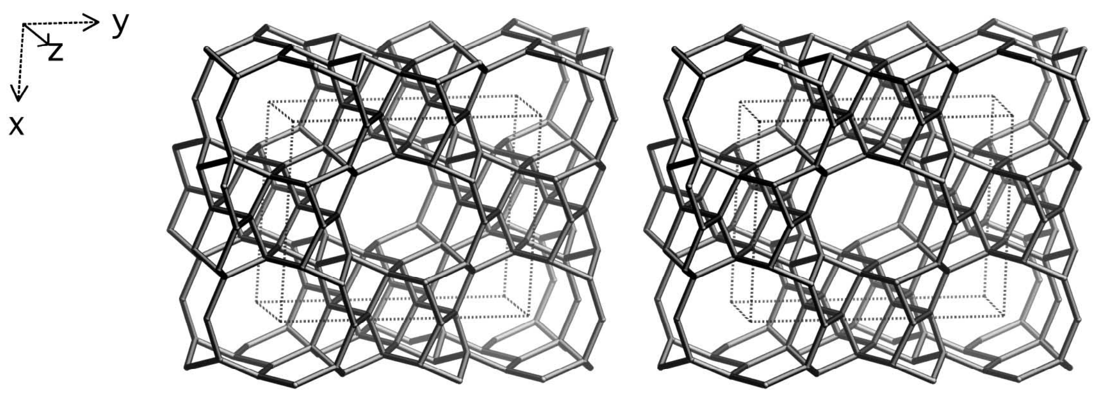
8-ring viewed along [100]



8-ring viewed along [010]



8-ring along [001] (variable)



framework viewed along [001]

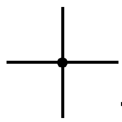
Idealized cell constants: orthorhombic, Cmcm, a = 14.1Å, b = 17.8Å, c = 5.3Å

Coordination sequences and vertex symbols:

T_1 (8, m)	4	12	24	40	61	96	133	163	204	262	$5_2\cdot6_2\cdot6\cdot6_2\cdot6\cdot6_2$
T_2 (8, m)	4	12	23	43	66	91	128	169	214	258	$5\cdot5\cdot5\cdot5\cdot6\cdot10_2$
T_3 (4, m2m)	4	12	22	41	68	97	118	166	224	258	$5\cdot5\cdot5\cdot5\cdot6_2\cdot10_2$
T_4 (4, m2m)	4	12	22	39	66	95	130	158	208	270	$5\cdot5\cdot5\cdot5\cdot6_2\cdot*$

Secondary building units: 6 or 5-1

Loop configuration of T-Atoms:



T_{1-4}

Isotypic framework structures:

*Theta-1[1,2]
ISI-1[3]
KZ-2[4]
NU-10[5]
ZSM-22[6,7]

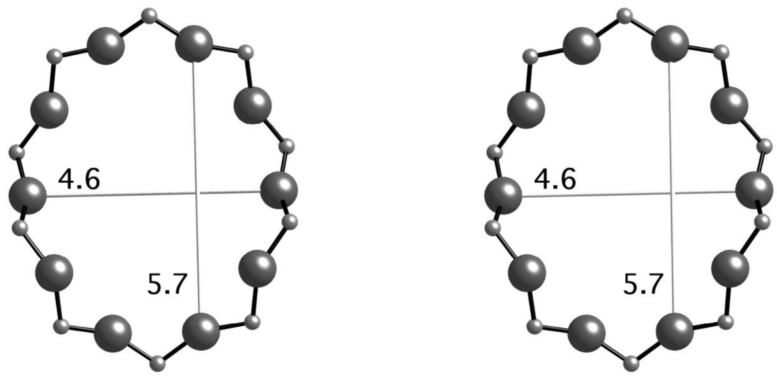
References:

(1) Barri, S.A.I., Smith, G.W., White, D. and Young, D. *Nature*, **312**, 533-534 (1984)
(2) Highcock, R.M., Smith, G.W. and Wood, D. *Acta Crystallogr.*, **C41**, 1391-1394 (1985)
(3) Kozo, T. and Noboru, K. *E. Patent A-170,003* (1986)
(4) Parker, L.M. and Bibby, D.M. *Zeolites*, **3**, 8-11 (1983)
(5) Araya, A. and Lowe, B.M. *Zeolites*, **4**, 280-286 (1984)
(6) Kokotailo, G.T., Schlenker, J.L., Dwyer, F.G. and Valyocsik, E.W. *Zeolites*, **5**, 349-351 (1985)
(7) Marler, B. *Zeolites*, **7**, 393-397 (1987)

Crystal chemical data: |Na^{+}_{n} $(H_2O)_4$| [Al_nSi_{24-n} O_{48}]-**TON**, n < 2
orthorhombic, $Cmc2_1$, a = 13.859Å, b = 17.420Å, c = 5.038Å [7]

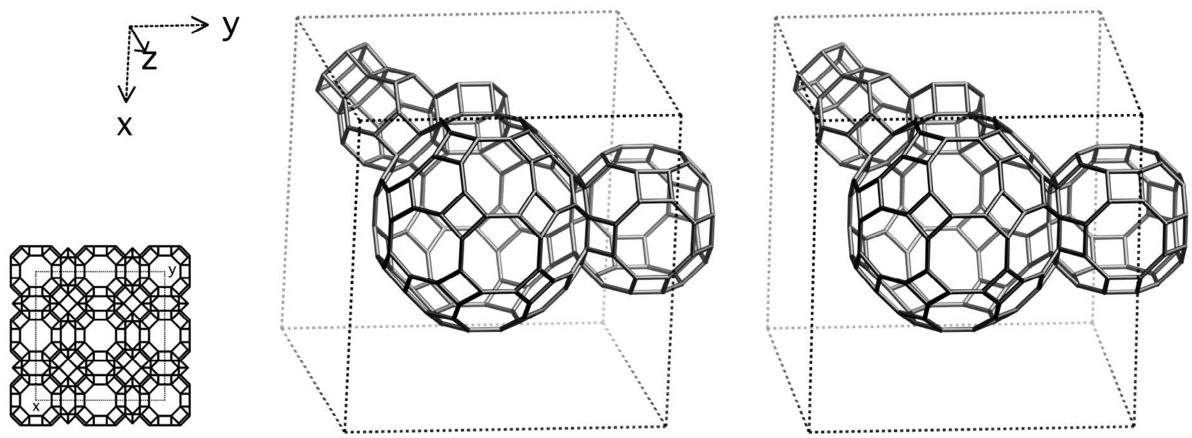
Framework density: 19.7 T/1000$Å^3$

Channels: [001] **10** 4.6 x 5.7*



10-ring viewed along [001]

TSC Framework Type $Fm\bar{3}m$



part of framework viewed along [001]

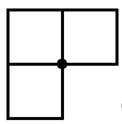
Idealized cell constants: cubic, $Fm\bar{3}m$, a = 30.7Å

Coordination sequences and vertex symbols:

T_1 (192, 1)	4	9	16	25	37	53	74	99	125	151	4·4·4·6·6·8
T_2 (192, 1)	4	9	17	28	41	56	73	93	117	146	4·4·4·8·6·8

Secondary building units: 6-6 or 6 or 4

Loop configuration of T-Atoms:



$T_{1,2}$

Isotypic framework structures: *Tschörtnerite[1]

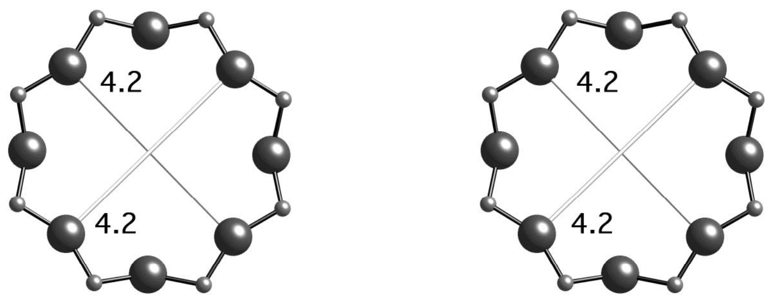
References:

(1) Effenberger, H., Giester, G., Krause, W. and Bernhardt, H.J. *Am. Mineral.*, **83**, 607-617 (1998)

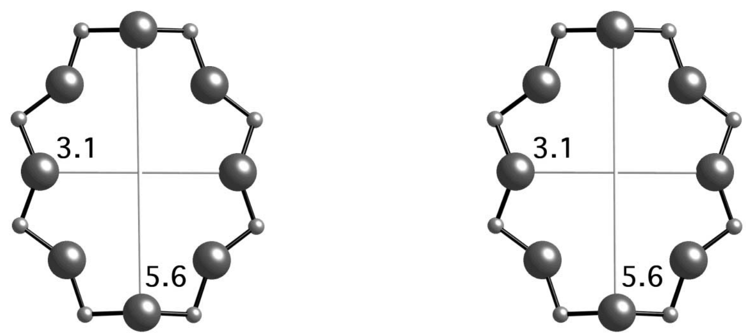
Crystal chemical data: **|**$Ca^{2+}_{64}(K^{+}_{2},Ca^{2+},Sr^{2+},Ba^{2+})_{48}Cu^{2+}_{48}$ $(OH)^{-}_{128}$ $(H_2O)_x$**|** **[**$Al_{192}Si_{192}$ O_{768}**]-TSC**
cubic, $Fm\bar{3}m$, a = 31.62Å [1]

Framework density: 12.1 T/1000$Å^3$

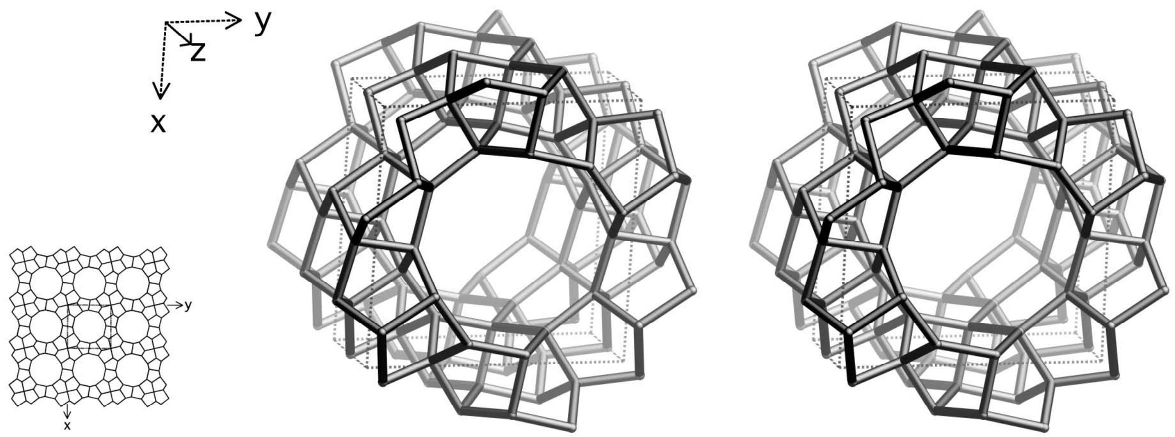
Channels: <100> **8** 4.2 x 4.2*** ↔ <110> **8** 3.1 x 5.6***



8-ring viewed along <100>



8-ring viewed along <110>



framework viewed along [001] (bottom left: projection down [001])

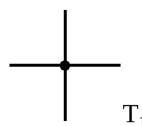
Idealized cell constants: tetragonal, P$\bar{4}$, a = 13.0Å, c = 4.9Å

Coordination sequences and vertex symbols:

T_1 (4, 1)	4	12	24	39	61	93	133	179	209	246	$5\cdot5\cdot5\cdot6_2\cdot5\cdot7$
T_2 (4, 1)	4	12	26	41	65	94	130	169	218	269	$5\cdot5\cdot5\cdot6\cdot7\cdot12_6$
T_3 (4, 1)	4	12	24	41	65	95	128	169	218	270	$5\cdot6\cdot5\cdot6\cdot5\cdot6_2$
T_4 (4, 1)	4	12	23	43	68	94	125	172	226	269	$5\cdot6\cdot5\cdot6\cdot5_2\cdot6$
T_5 (1, $\bar{4}$)	4	12	28	38	60	98	152	182	200	246	$5\cdot5\cdot5\cdot5\cdot8_2\cdot8_2$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *VPI-8[1]

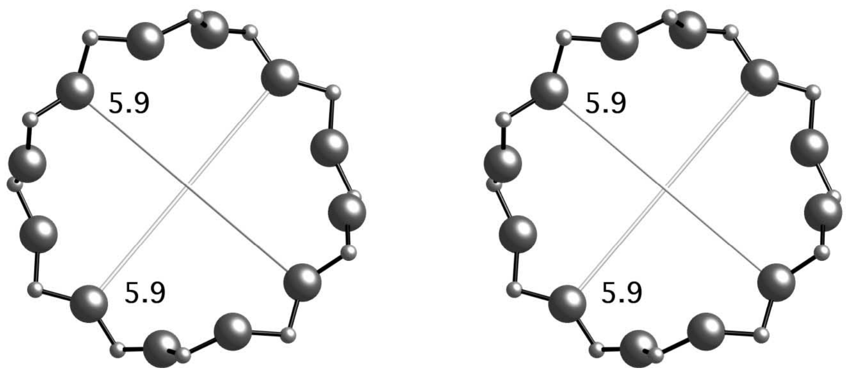
References:

(1) Freyhardt, C.C., Lobo, R.F., Khodabandeh, S., Lewis, J.E., Tsapatsis, M., Yoshikawa, M., Camblor, M.A., Pan, M., Helmkamp, M.M., Zones, S.I. and Davis, M.E. *J. Am. Chem. Soc.*, **118**, 7299-7310 (1996)

Crystal chemical data: **[**Si_{17} O_{34}**]-VET**
tetragonal, P$\bar{4}$, a = 13.045Å, c = 5.034Å [(1)]

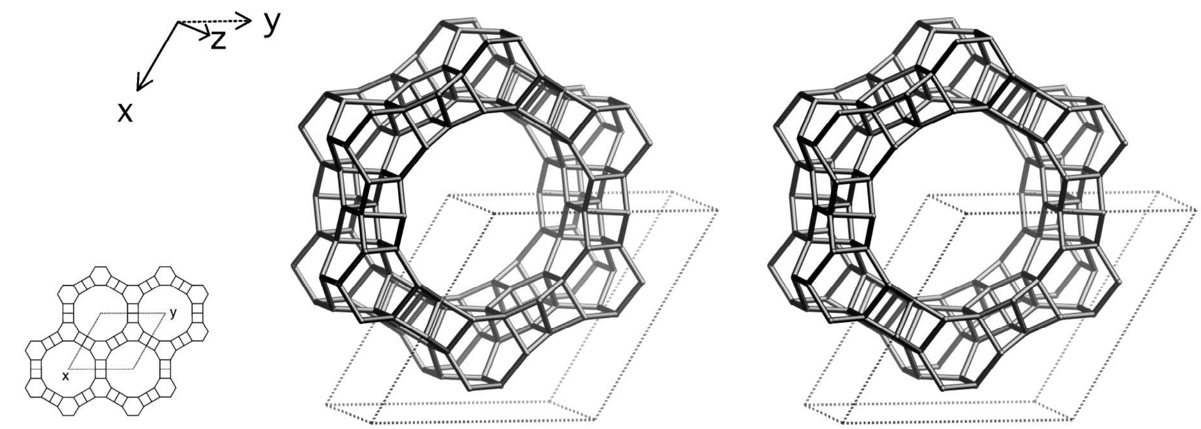
Framework density: 19.8 T/1000Å^3

Channels: [001] **12** 5.9 x 5.9*



12-ring viewed along [001]

VFI Framework Type $P6_3/mcm$



framework viewed along [001]

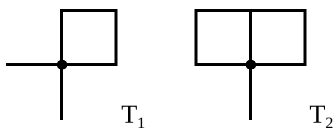
Idealized cell constants: hexagonal, $P6_3/mcm$, a = 18.3Å, c = 8.6Å

Coordination sequences and vertex symbols:

T_1 (24, 1)	4	11	20	31	44	61	82	108	139	174	$4 \cdot 6_2 \cdot 6 \cdot 6_3 \cdot 6_2 \cdot 6_3$
T_2 (12, m)	4	10	18	30	44	60	80	106	135	168	$4 \cdot 6_3 \cdot 4 \cdot 6_3 \cdot 6 \cdot 6_4$

Secondary building units: 6

Loop configuration of T-Atoms:



Isotypic framework structures:

*VPI-5[1-3]
AlPO-54[4]
H1[5]
MCM-9[6]

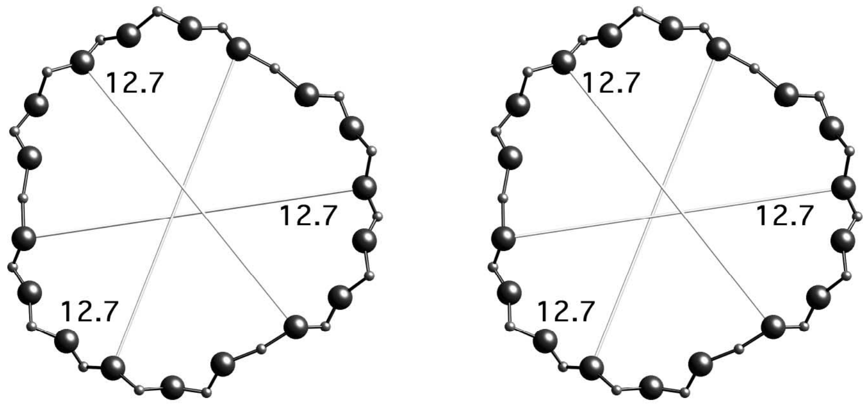
References:

(1) Davis, M.E., Saldarriaga, C., Montes, C., Garces, J. and Crowder, C. *Nature*, **331**, 698-699 (1988)
(2) Richardson Jr., J.W., Smith, J.V. and Pluth, J.J. *J. Phys. Chem.*, **93**, 8212-8219 (1989)
(3) McCusker, L.B., Baerlocher, Ch., Jahn, E. and Bülow, M. *Zeolites*, **11**, 308-313 (1991)
(4) Richardson Jr., J.W., Smith, J.V. and Pluth, J.J. *J. Phys. Chem.*, **93**, 8212-8219 (1989)
(5) d'Yvoire, F. *Bull. Soc. Chim. France*, 1762-1776 (1961)
(6) Derouane, E.G., Maistreiau, L., Gabelica, Z., Tuel, A., Nagy, J.B. and von Ballmoos, R. *Appl. Catal.*, **51**, L13-L20 (1989)

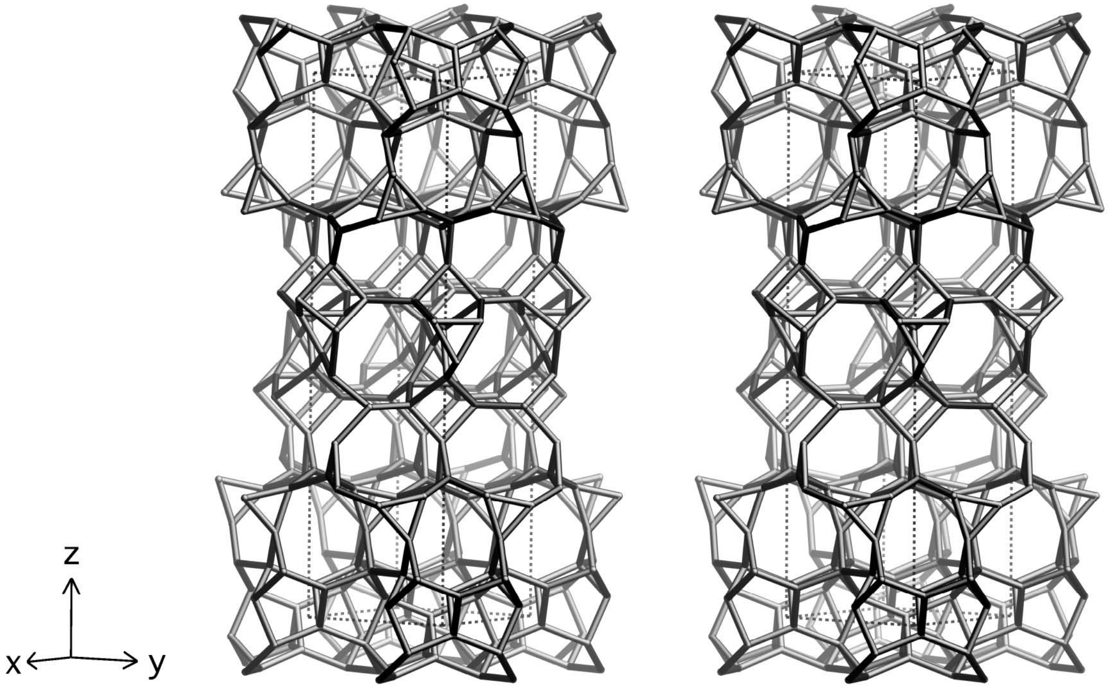
Crystal chemical data: **|**$(H_2O)_{42}$**|** **[**$Al_{18}P_{18}O_{72}$**]-VFI**
hexagonal, $P6_3$, a = 18.975Å, c = 8.104Å [(3)]

Framework density: 14.2 T/1000Å^3

Channels: [001] **18** 12.7 x 12.7*



18-ring viewed along [001]



framework viewed along [110]

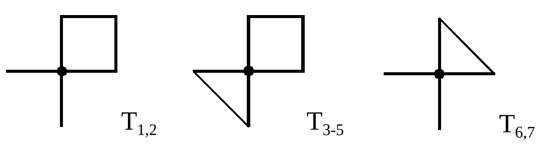
Idealized cell constants: tetragonal, $P4_2/ncm$ (origin choice 2), a = 10.0Å, c = 34.1Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	11	23	39	63	93	126	170	210	255	$4 \cdot 8 \cdot 5 \cdot 8_2 \cdot 5_2 \cdot 8_2$
T_2 (8, m)	4	11	19	39	59	89	130	166	207	274	$4 \cdot 5_2 \cdot 5 \cdot 8 \cdot 5 \cdot 8$
T_3 (8, m)	4	9	20	37	61	92	117	152	201	246	$3 \cdot 4 \cdot 8 \cdot 8_2 \cdot 8 \cdot 8_2$
T_4 (8, m)	4	9	20	37	62	87	119	158	195	248	$3 \cdot 4 \cdot 8_2 \cdot 8_3 \cdot 8_2 \cdot 8_3$
T_5 (8, m)	4	9	21	41	59	85	133	155	195	261	$3 \cdot 4 \cdot 8 \cdot 8_3 \cdot 8 \cdot 8_3$
T_6 (8, m)	4	10	18	39	65	83	119	169	218	236	$3 \cdot 8_3 \cdot 5 \cdot 5_2 \cdot 5 \cdot 5_2$
T_7 (4, 2mm)	4	10	18	36	64	82	118	176	202	264	$3 \cdot 8_2 \cdot 5 \cdot 5 \cdot 5 \cdot 5$

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *VPI-9[1]

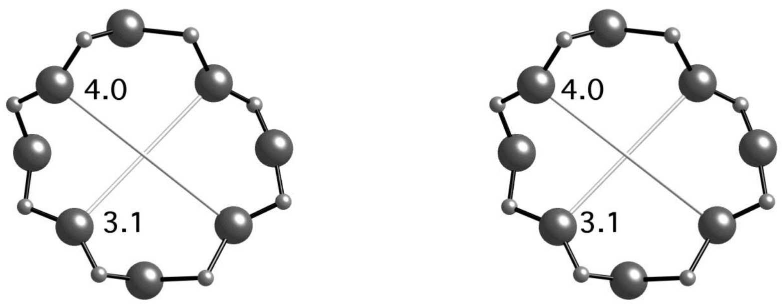
References:

(1) McCusker, L.B., Grosse-Kunstleve, R.W., Baerlocher, Ch., Yoshikawa, M. and Davis, M.E. *Microporous Materials*, **6**, 295-309 (1996)

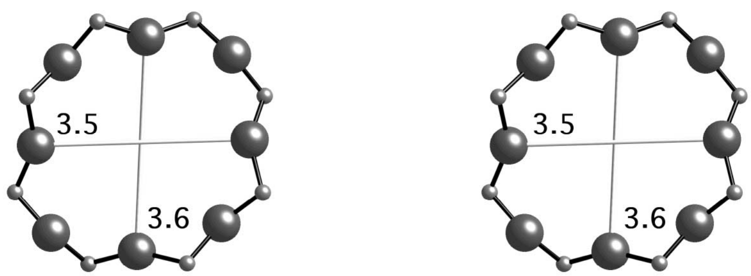
Crystal chemical data: **|**$Rb^{+}_{44}K^{+}_{4}$ $(H_2O)_{48}$**|** **[**$Zn_{24}Si_{96}$ O_{240}**]-VNI**
tetragonal, $P4_12_12$, a = 9.884Å, c = 73.650Å [(1)]
(Relationship to unit cell of Framework Type: a' = a, b' = b, c' = 2c)

Framework density: 16.7 T/1000Å^3

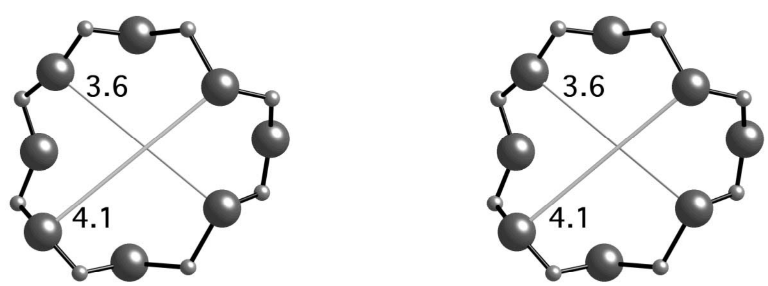
Channels: {<110> **8** 3.1 x 4.0 ↔ [001] **8** 3.5 x .3.6}***



8-ring along <110>

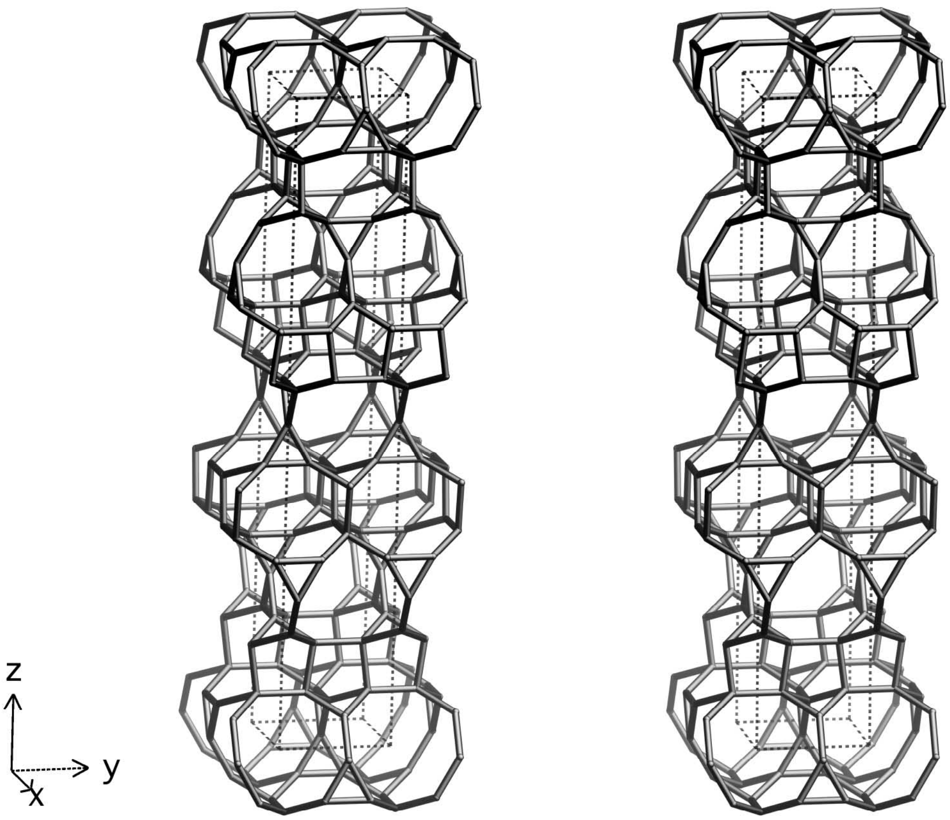


8-ring viewed along [001]



2nd 8-ring along <110>

VSV Framework Type $I4_1/amd$



framework viewed along [100]

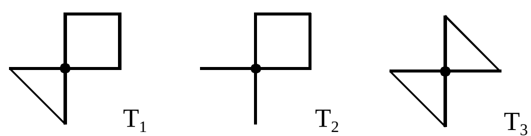
Idealized cell constants: tetragonal, $I4_1/amd$, a = 7.2Å, c = 41.8Å

Coordination sequences and vertex symbols:

T_1 (16, m)	4	9	21	42	61	81	123	159	198	246		$3 \cdot 4 \cdot 8_2 \cdot 9_4 \cdot 8_2 \cdot 9_4$
T_2 (16, m)	4	11	21	40	61	93	122	151	195	251		$4 \cdot 5_2 \cdot 5 \cdot 8 \cdot 5 \cdot 8$
T_3 (4, $\bar{4}m2$)	4	8	20	48	56	84	120	160	212	240		$3 \cdot 3 \cdot 9_4 \cdot 9_4 \cdot 9_4 \cdot 9_4$

Secondary building units: combinations only

Loop configuration of T-Atoms:



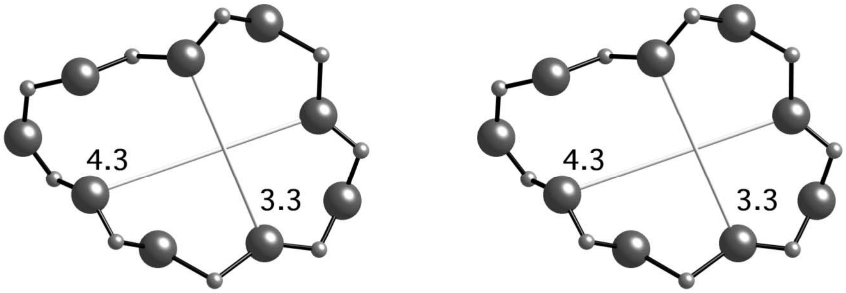
Isotypic framework structures:

*VPI-7[1,2]
Gaultite[3]
VSV-7#[4]

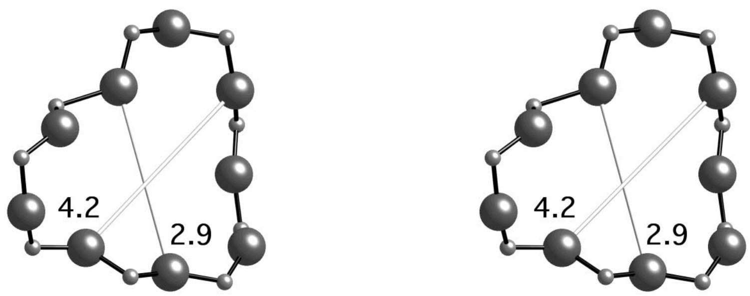
Crystal chemical data: $|Na^{+}_{26}H^{+}_{6}(H_2O)_{44}|$ **[**$Zn_{16}Si_{56}O_{144}$**]-VSV**
orthorhombic, Fdd2, a = 39.88Å, b = 10.326Å, c = 10.219Å [(2)]
(Relationship to unit cell of Framework Type:
a' = c, b = a sqrt(2), c' = b sqrt(2)
or, as vectors, **a** = **c** , **b** = **b** - **a**, **c** = **a** + **b**)

Framework density: 17.1 T/1000Å^3

Channels: [01$\bar{1}$] **9** 3.3 x 4.3* ↔ [011] **9** 2.9 x 4.2*↔ [011] **8** 2.1 x 2.7*



9-ring along [01¯]

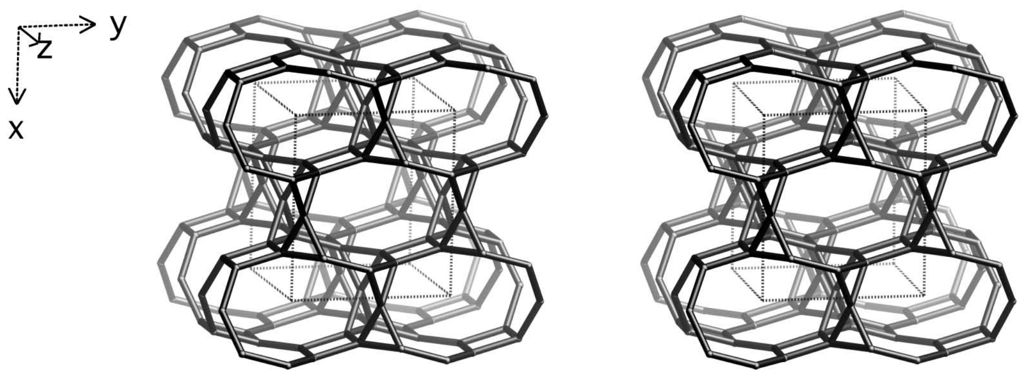


9-ring along [011]

See Appendix A for 8-ring along [011] and 8-ring viewed along [100]

References:
(1) Annen, M.J., Davis, M.E., Higgins, J.B. and Schlenker, J.L. *Chem. Commun.*, 1175-1176 (1991)
(2) Röhrig, C., Gies, H. and Marler, B. *Zeolites*, **14**, 498-503 (1994)
(3) Ercit, T.S. and van Velthuizen, J. *Can. Mineral.*, **32**, 855-863 (1994)
(4) Röhrig, C., Dierdorf, I. and Gies, H. *J. Phys. Chem. Solids*, **56**, 1369-1376 (1995)

WEI Framework Type Cccm



framework viewed along [001]

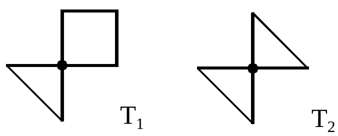
Idealized cell constants: orthorhombic, Cccm, a = 11.8Å, b = 10.3Å, c = 10.0Å

Coordination sequences and vertex symbols:

T_1 (16, 1)	4	9	18	32	51	74	98	126	163	199	3·4·6·8·8·10
T_2 (4, 222)	4	8	18	32	52	70	98	132	152	200	3·3·6·6·10·10

Secondary building units: spiro-5

Loop configuration of T-Atoms:



Isotypic framework structures: *Weinebeneite[1]

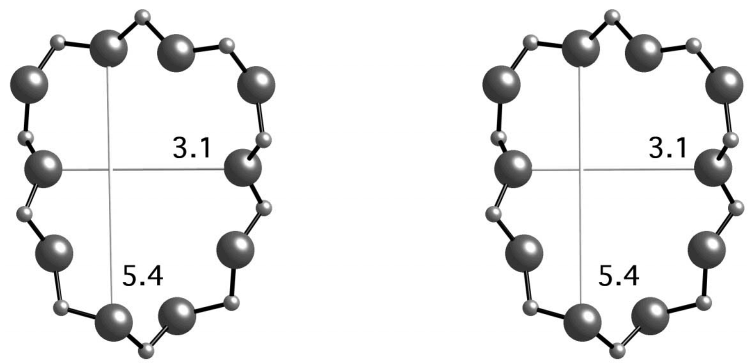
References:

(1) Walter, F. *Eur. J. Mineral.*, **4**, 1275-1283 (1992)

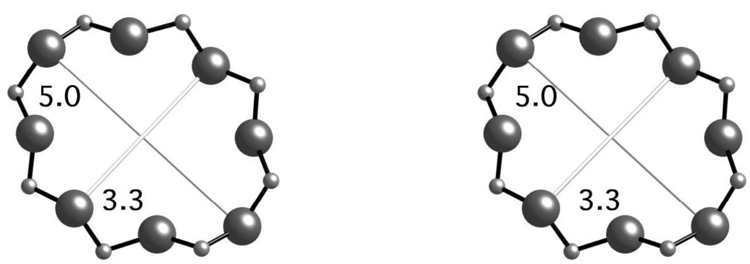
Crystal chemical data: |Ca^{2+}_4 $(H_2O)_{16}$| **[**$Be_{12}P_8$ $O_{32}(OH)_8$**]-WEI**
monoclinic, C1c1, a = 11.897Å, b = 9.707Å, c = 9.633Å, β = 95.76° [(1)]

Framework density: 18.1 T/1000$Å^3$

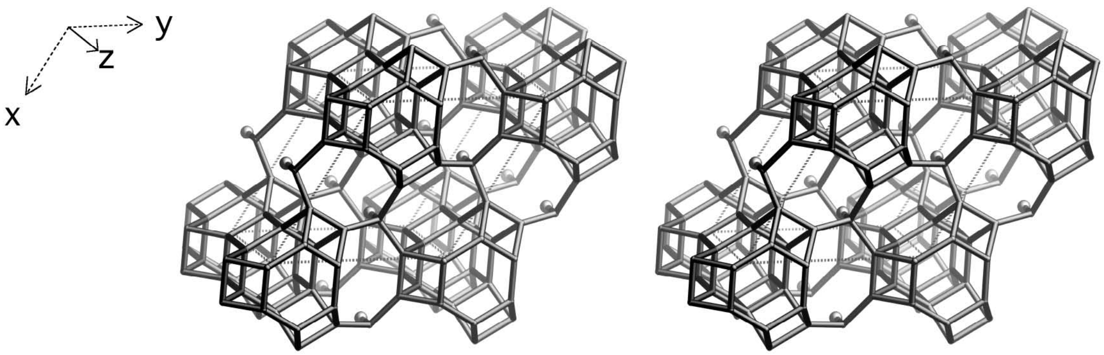
Channels: [001] **10** 3.1 x 5.4* ↔ [100] **8** 3.3 x 5.0*



10-ring viewed along [001]



8-ring viewed along [100]



framework viewed along [001]

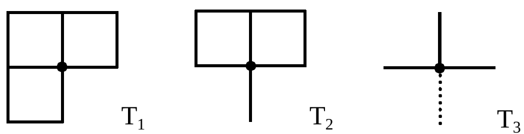
Idealized cell constants: hexagonal, P$\bar{6}$2m, a = 13.6Å, c = 7.6Å

Coordination sequences and vertex symbols:

T_1 (12, 1)	4	9	16	27	46	73	102	129	157	191
T_2 (6, m)	4	9	19	34	49	67	94	125	157	195
T_3 (2, 3)	3	9	21	36	53	69	90	119	156	201

Secondary building units: combinations only

Loop configuration of T-Atoms:



Isotypic framework structures: *Wenkite[1,2]

References:

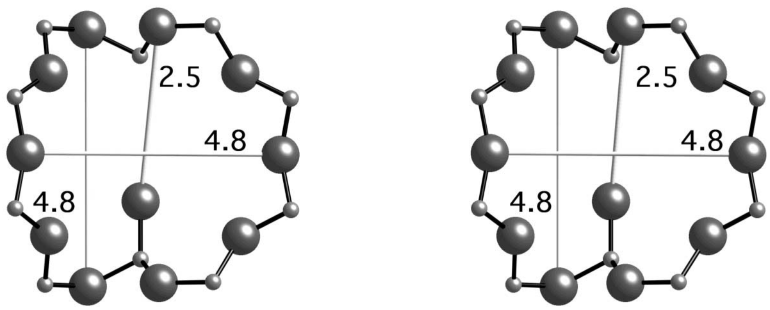
(1) Wenk, H.-R. *Z. Kristallogr.*, **137**, 113-126 (1973)
(2) Merlino, S. *Acta Crystallogr.*, **B30**, 1262-1266 (1974)

Wenkite Type Material -WEN

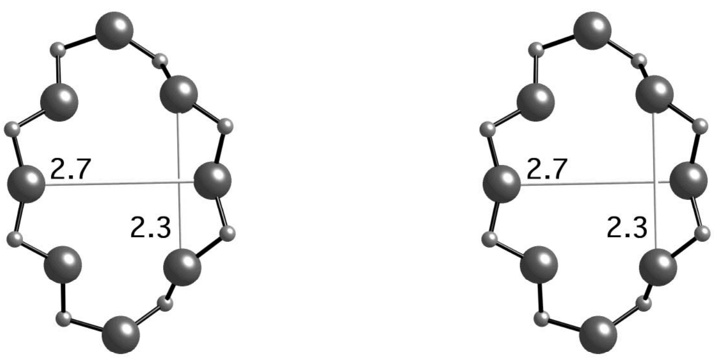
Crystal chemical data: $|Ba^{2+}_4(Ca^{2+},Na^{+}_2)_3\ (SO_4^{2-})_3\ H_2O|\ [Al_8Si_{12}\ O_{39}(OH)_2]$- **-WEN**
hexagonal, $P\bar{6}2m$, a = 13.511Å, c = 7.462Å (2)

Framework density: 17 T/1000Å^3

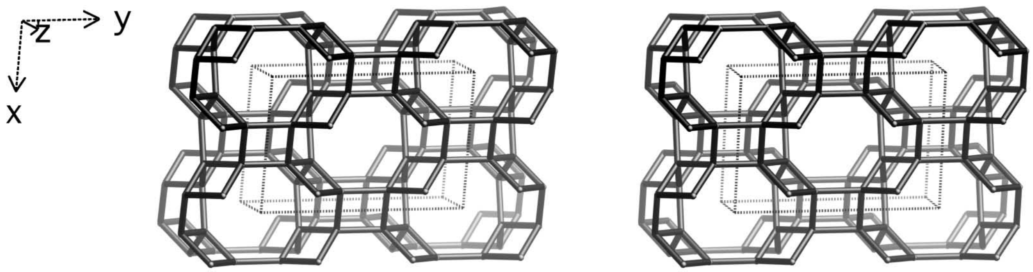
Channels: <100> **10** 2.5 x 4.8** ↔ [001] **8** 2.3 x 2.7*



10-ring viewed along <100>



8-ring viewed along [001]



framework viewed along [001]

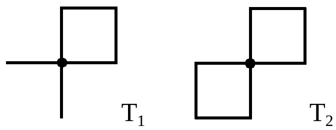
Idealized cell constants: monoclinic, C2/m, a = 10.2Å, b = 13.8Å, c = 6.8Å, β = 111.5°

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	11	22	39	61	88	120	155	192	241	4·5·5·5·8·8
T_2 (8, 1)	4	10	22	39	61	89	118	153	198	241	$4·4·5·8_2·5·8_2$

Secondary building units: 8 or 4

Loop configuration of T-Atoms:



Isotypic framework structures: *Yugawaralite[1-3]
Sr-Q[4,5]

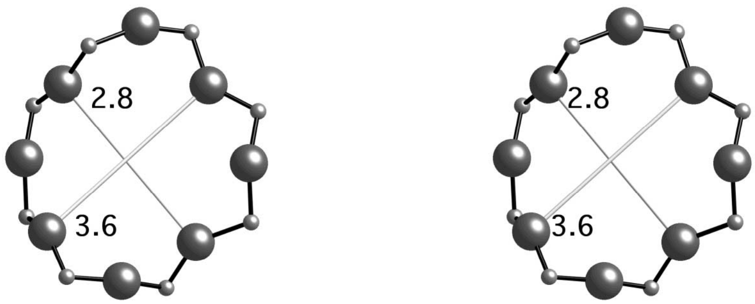
References:

(1) Kerr, I.S. and Williams, D.J. *Z. Kristallogr.*, **125**, 220-225 (1967)
(2) Kerr, I.S. and Williams, D.J. *Acta Crystallogr.*, **B25**, 1183-1190 (1969)
(3) Leimer, H.W. and Slaughter, M. *Z. Kristallogr.*, **130**, 88-111 (1969)
(4) Hawkins, D.B. *Mater. Res. Bull.*, **2**, 951-958 (1967)
(5) Kvick, Å., Artioli, G. and Smith, J.V. *Z. Kristallogr.*, **174**, 265-281 (1986)

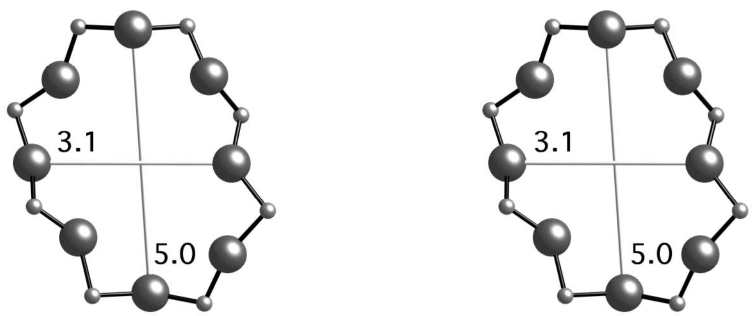
Crystal chemical data: |$Ca^{2+}{}_2$ $(H_2O)_8$| **[**Al_4Si_{12} O_{32}**]-YUG**
monoclinic, Pc, a = 6.73Å, b = 13.95Å, c = 10.03Å, β = 111.5° (2)
(Relationship to unit cell of Framework Type: a' = c, b' = b, c' = a)

Framework density: 18.3 T/1000$Å^3$

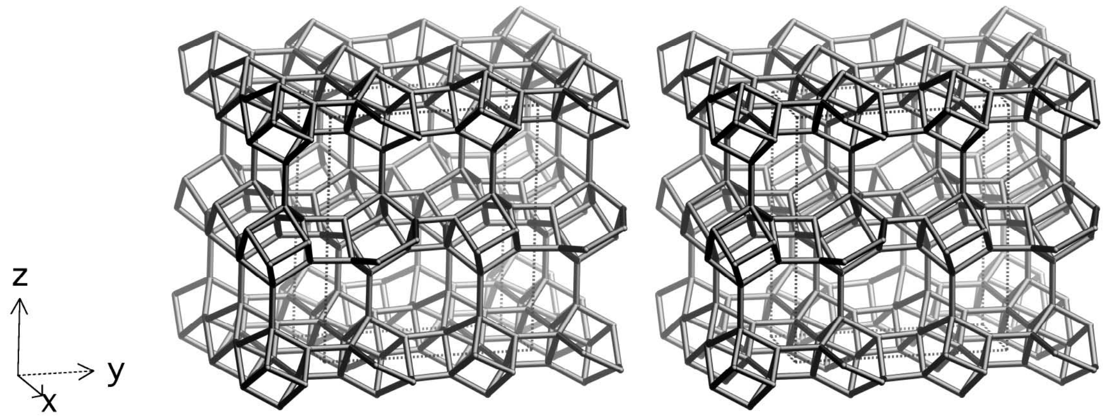
Channels: [100] **8** 2.8 x 3.6* ↔ [001] **8** 3.1 x 5.0*



8-ring viewed along [100]



8-ring viewed along [001]



framework viewed along [100]

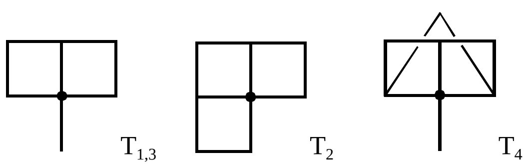
Idealized cell constants: orthorhombic, Pbcm, a = 6.9Å, b = 14.9Å, c = 17.2Å

Coordination sequences and vertex symbols:

T_1 (8, 1)	4	10	21	34	47	72	108	136	162	200	$4·8·4·8_2·6_3·8$
T_2 (8, 1)	4	9	19	33	53	78	100	126	166	213	$4·4·4·8·6·6_3$
T_3 (8, 1)	4	10	18	33	57	77	95	129	172	209	$4·6·4·6·6·8$
T_4 (8, 1)	4	9	17	32	53	74	98	128	165	208	$4·6·4·6_2·4·8$

Secondary building units: 6-2 or 4

Loop configuration of T-Atoms:



Isotypic framework structures:
*ZAPO-M1[1]
GaPO-DAB-2[2]
UiO-7[3,4]

References:

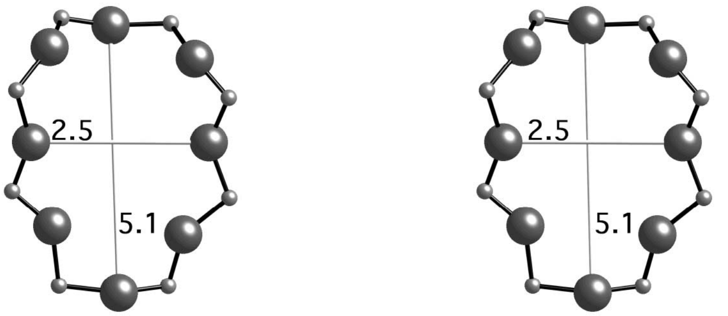
(1) Marler, B., Patarin, J. and Sierra, L. *Microporous Materials*, **5**, 151-159 (1995)
(2) Meden, A., Grosse-Kunstleve, R.W., Baerlocher, Ch. and McCusker, L.B. *Z. Kristallogr.*, **212**, 801-807 (1997)
(3) Akporiaye, D.E., Fjellvåg, H., Halvorsen, E.N., Hustveit, J., Karlsson, A. and Lillerud, K.P. *Chem. Commun.*, 601-602 (1996)
(4) Akporiaye, D.E., Fjellvåg, H., Halvorsen, E.N., Hustveit, J., Karlsson, A. and Lillerud, K.P. *J. Phys. Chem.*, **100**, 16641-16646 (1996)

ZAPO-M1 **Type Material** **ZON**

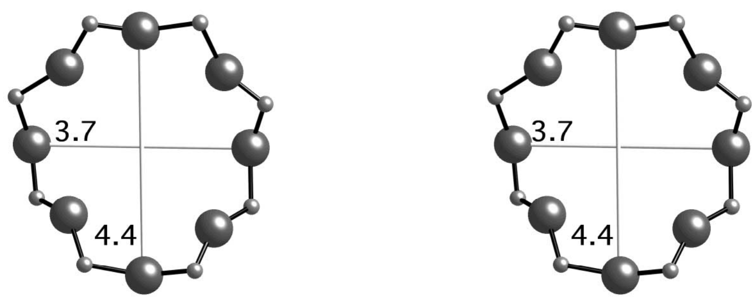
Crystal chemical data: |$(C_4H_{12}N^+)_8$| [$Zn_8Al_{24}P_{32}O_{128}$]-**ZON**
$C_4H_{12}N^+$ = tetramethylammonium
orthorhombic, Pbca, a = 14.226Å, b = 15.117Å, c = 17.557Å [(1)]
(Relationship to unit cell of Framework Type: a' = 2a, b' = b, c' = c)

Framework density: 17 T/1000Å^3

Channels: [100] **8** 2.5 x 5.1* ↔ [010] **8** 3.7 x 4.4*



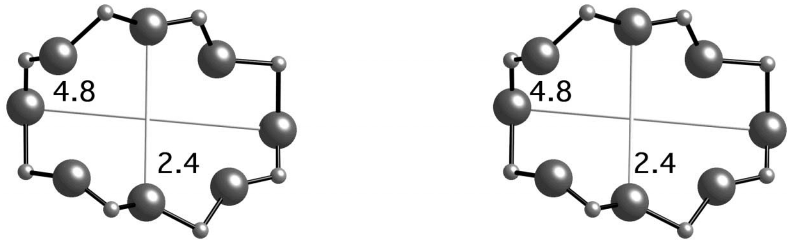
8-ring viewed along [100]



8-ring viewed along [010]

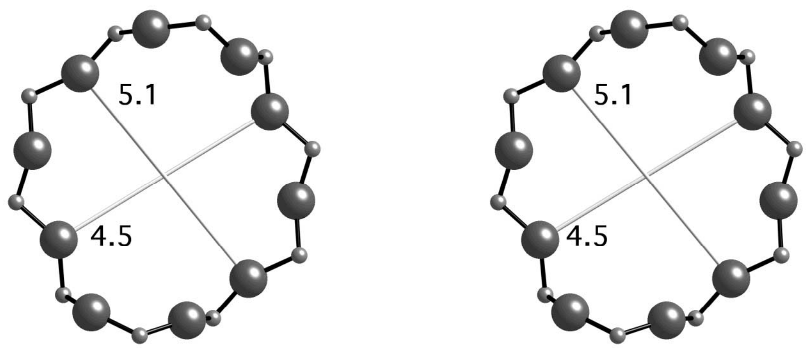
APPENDIX A

CGF

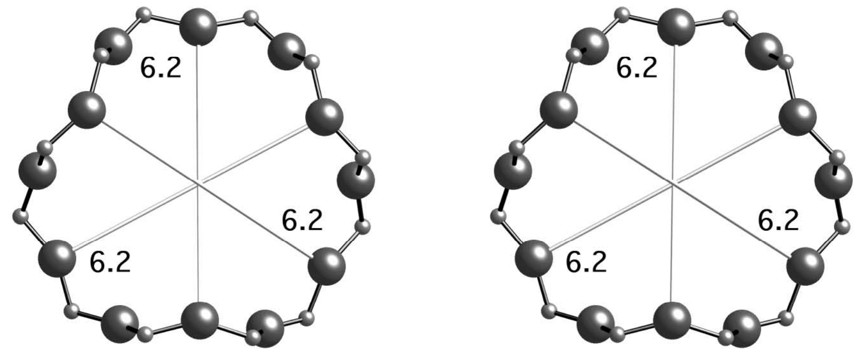


8-ring viewed along [001]

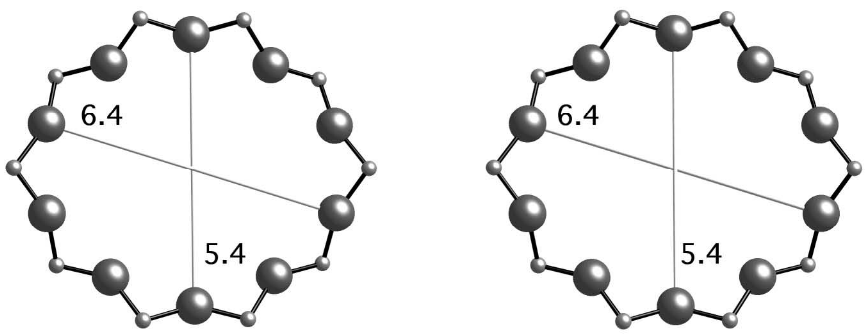
CON



10-ring viewed along [010]

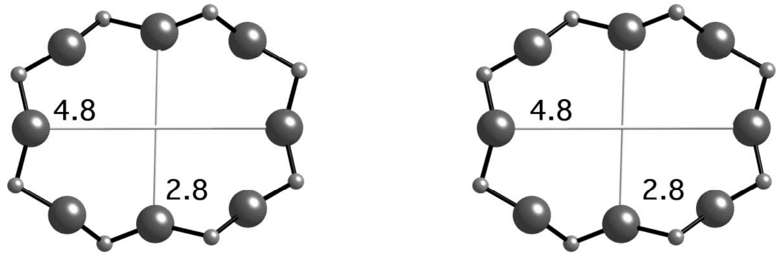


2nd 12-ring viewed along [001]



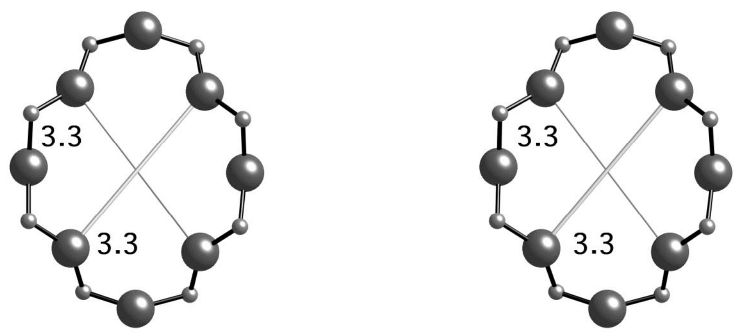
10-ring viewed normal to [001]

GIS



8-ring viewed along [010]

MER



2nd 8-ring viewed along [001]

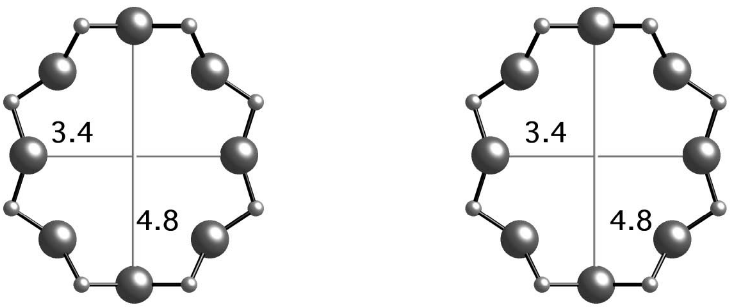
Isotypic framework structures:

[As-Si-O**]-MFI**[4]
[Fe-Si-O**]-MFI**[5]
[Ga-Si-O**]-MFI**[6]
AMS-1B[7]
AZ-1[8]
Bor-C[9]
Boralite C[10]
Encilite[11]
FZ-1[12]
LZ-105[13]
Monoclinic H-ZSM-5[14]
Mutinaite[15]
NU-4[16]
NU-5[17]
Silicalite[18]
TS-1[19]
TSZ[20]
TSZ-III[21]
TZ-01[22]
USC-4[23]
USI-108[24]
ZBH[25]
ZKQ-1B[26]
ZMQ-TB[27]

References:

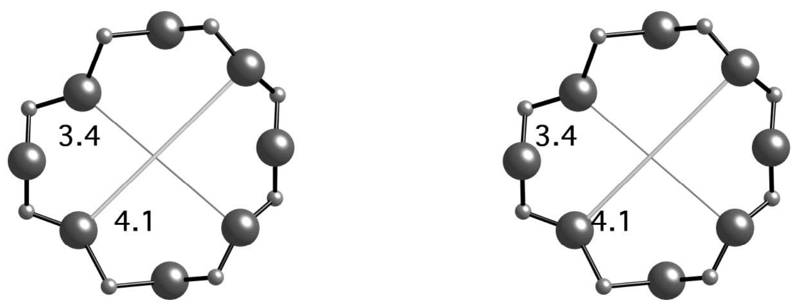
(4) Bhaumik, A. and Kumar, R. *Chem. Commun.*, 869-870 (1995)
(5) Patarin, J., Kessler, H. and Guth, J.L. *Zeolites*, **10**, 674-679 (1990)
(6) Awate, S.V., Joshi, P.N., Shiralkar, V.P. and Kotasthane, A.N. *J. Incl. Phenom.*, **13**, 207-218 (1992)
(7) Klotz, M.R. *U.S. Patent 4,269,813* (1981)
(8) Chono, M. and Ishida, H. *E. Patent B-113,116* (1984)
(9) Taramasso, M., Perego, G. and Notari, B. In *Proc. 5th Int. Zeolite Conf.*, (ed. L.V.C. Rees), pp. 40-48 (1980), Heyden, London
(10) Taramasso, M., Manara, G., Fattore, V. and Notari, B. *GB Patent 2,024,790* (1980)
(11) Ratnasamy, P. and Borade, M.B. *E. Patent A-160,136* (1985)
(12) Suzuki, T., Hashimoto, S. and Nakano, R. *E. Patent B-31,255* (1981)
(13) Grose, R.W. and Flanigen, E.M. *U.S. Patent 4,257,885* (1981)
(14) van Koningsveld, H., Jansen, J.C. and van Bekkum, H. *Zeolites*, **10**, 235-242 (1990)
(15) Vezzalini, G., Quartieri, S., Galli, E., Alberti, A., Cruciani, G. and Kvick, A. *Zeolites*, **19**, 323-325 (1997)
(16) Whittam, T.V. *E. Patent B-65,401* (1986)
(17) Whittam, T.V. *E. Patent B-54,386* (1982)
(18) Flanigen, E.M., Bennett, J.M., Grose, R.W., Cohen, J.P., Patton, R.L., Kirchner, R.M. and Smith, J.V. *Nature*, **271**, 512-516 (1978)
(19) Taramasso, M., Perego, G. and Notari, B. *U.S. Patent 4,410,501* (1983)
(20) Ashibe, K., Kobayashi, W., Maejima, T., Sakurada, S. and Tagaya, N. *E. Patent A-101,232* (1984)
(21) Sakurada, S., Tagaya, N., Miura, T., Maeshima, T. and Hashimoto, T. *E. Patent A-170,751* (1986)
(22) Iwayama, K., Kamano, T., Tada, K. and Inoue, T. *E. Patent A-57,016* (1982)
(23) Young, D.A. *U.S. Patent 4,325,929* (1982)
(24) Hinnenkamp, J.A. and Walatka, V.V. *U.S. Patent 4,423,020* (1983)
(25) Holderich, W., Mross, W.D. and Schwartzmann, M. *E. Patent B-77,946* (1986)
(26) Kee Kwee, L.S.L. *E. Patent A-148,038* (1984)
(27) Kee Kwee, L.S.L. *E. Patent A-104,107* (1983)

MOR



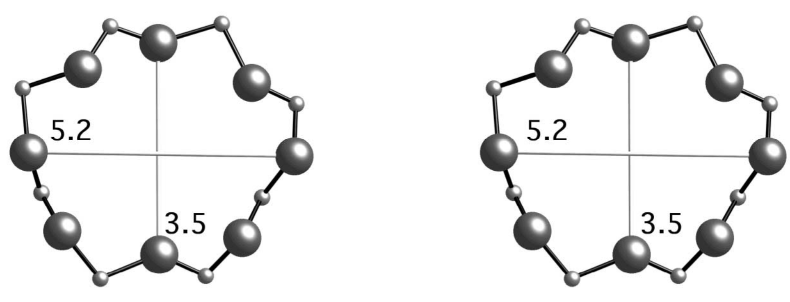
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RSN



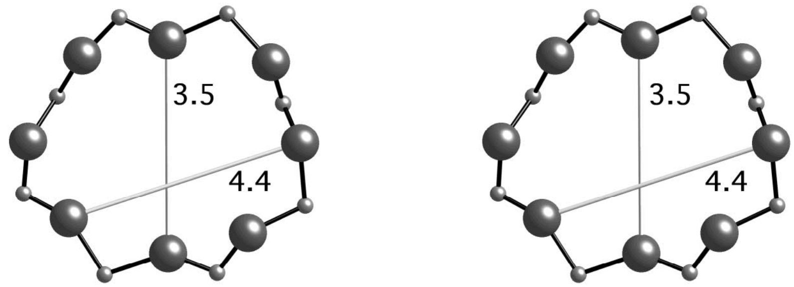
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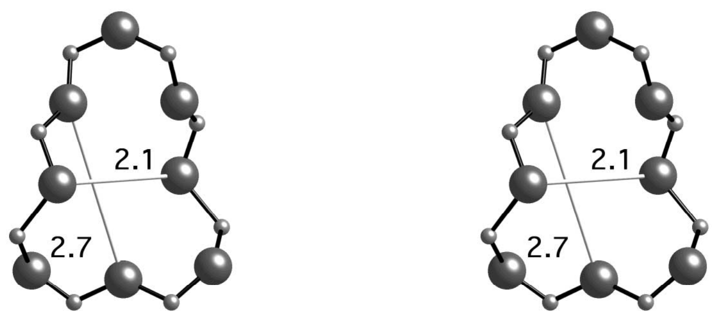
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SBT

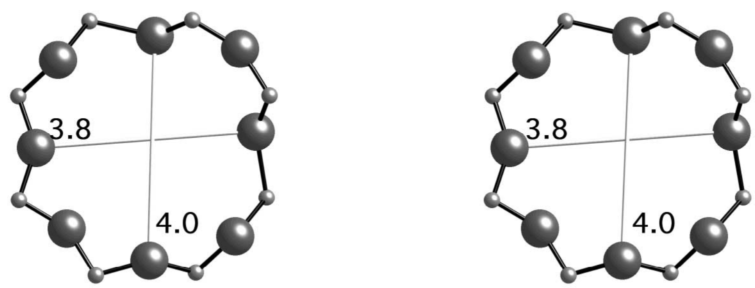


8-ring viewed along [102]

VSV



8-ring along [011]



8-ring viewed along [100]

APPENDIX B

Rules for Framework Type Assignment

The following is a set of rules to be applied by the Structure Commission of the IZA in assigning a three-letter code to a new framework type. The materials of interest are generally defined as open 4-connected 3D nets which have the general (approximate) composition AB_2, where A is a tetrahedrally connected atom and B is any 2-connected atom, which may or may not be shared, between two neighboring A atoms. Inclusion of other microporous materials is left to the discretion of the IZA Structure Commission, depending on the interest of the molecular sieve science community at large.

RULES

(i) The IZA Structure Commission is the only body that can coordinate the assignment of a code to such frameworks. The framework types are idealized, with no reference to actual materials, symmetry, composition, etc. and, therefore, ONLY refer to the connectivity.

(ii) The code for a 4-connected 3D framework type shall consist of three capital letters. Other frameworks of interest shall be indicated by a (-) in front of the code.

(iii) The three letters of the code shall be mnemonic and must refer to an actual material (i.e. the type material). These materials are chosen to be:

- mineral names (rules of the International Mineralogical Association followed).
- commonly accepted synthetic material types.
- in the absence of the above, the workers who first determined the structure have priority in assigning the name.

(iv) No mnemonic code can be assigned without the structure being determined with the following exception:

For "polytypic" materials, codes can be assigned as useful. Such codes shall be marked with an asterisk.

(v) Codes of framework types which turn out to be in error are discredited. Later use of the code is not permitted.

(vi) For all cases where a decision of the Structure Commission is required, a two thirds majority vote of the full commission shall be required. Such votes are taken verbally at a meeting of the Structure Commission or are done in writing on the initiative of the Chairperson and Co-chairperson. All evidence substantiating a new framework type must accompany the ballot. The members are obliged to respond to this request within one month and the Chairperson and Co-chairperson will make all possible effort to solicit replies from all members.

APPENDIX C

Topological Densities

Topological density values TD_{10} including all values of the coordination sequence from N_0 to N_{10}.
TD = exact density as defined in the Explanatory Notes.

Code	TD_{10}	TD	Code	TD_{10}	TD	Code	TD_{10}	TD
ABW	833	0.703704	**DFO**	664	0.576042	**MTW**	912	0.776004
ACO	787	0.666667	**DFT**	840	0.711111	**MWW**	851	0.752127
AEI	689	0.583081	**DOH**	1002	0.882191	**NAT**	834	0.740741
AEL	904	0.766975	**DON**	851	0.728920	**NES**	922	0.818688
AEN	956	0.857768	**EAB**	735	0.628571	**NON**	1038	0.915319
AET	824	0.697917	**EDI**	786	0.666667	**OFF**	739	0.628571
AFG	816	0.693333	**EMT**	584	0.493095	**OSI**	892	0.777778
AFI	828	0.700000	**EPI**	979	0.845059	**OSO**	747	0.645000
AFN	777	0.661111	**ERI**	738	0.628571	**-PAR**	773	0.664915
AFO	907	0.769676	**ESV**	875	0.754994	**PAU**	728	0.623377
AFR	687	0.579229	**EUO**	965	0.872973	**PHI**	751	0.635556
AFS	656	0.568750	**FAU**	579	0.476190	**RHO**	641	0.533333
AFT	685	0.585714	**FER**	1021	0.887635	**-RON**	771	0.688981
AFX	689	0.585714	**FRA**	802	0.683983	**RSN**	914	0.786947
AFY	585	0.488889	**GIS**	726	0.611111	**RTE**	844	0.715873
AHT	853	0.729167	**GME**	694	0.585714	**RTH**	817	0.695757
ANA	933	0.800000	**GON**	926	0.787372	**RUT**	902	0.767499
APC	814	0.696296	**GOO**	840	0.716755	**SAO**	632	0.545455
APD	888	0.759019	**HEU**	909	0.778254	**SAS**	701	0.586667
AST	742	0.625000	**IFR**	798	0.678236	**SAT**	763	0.644444
ASV	787	0.666667	**ISV**	772	0.694533	**SAV**	690	0.587302
ATN	833	0.703704	**ITE**	824	0.711802	**SBE**	619	0.514323
ATO	894	0.760000	**JBW**	890	0.753333	**SBS**	617	0.534092
ATS	752	0.640000	**KFI**	681	0.571429	**SBT**	617	0.522344
ATT	768	0.647619	**LAU**	782	0.658201	**SFE**	892	0.767358
ATV	960	0.816667	**LEV**	719	0.605714	**SFF**	880	0.765073
AWO	828	0.708843	**LIO**	816	0.693333	**SGT**	962	0.862901
AWW	772	0.656085	**LOS**	816	0.693333	**SOD**	791	0.666667
***BEA**	805	0.704545	**LOV**	879	0.754446	**STF**	877	0.748986
BIK	1052	0.907407	**LTA**	641	0.533333	**STI**	852	0.720342
BOG	781	0.659922	**LTL**	746	0.619048	**STT**	859	0.760705
BPH	667	0.568750	**LTN**	779	0.698452	**TER**	872	0.739316
BRE	901	0.778031	**MAZ**	823	0.697032	**THO**	784	0.666667
CAN	817	0.693333	**MEI**	728	0.630682	**TON**	1006	0.867111
CAS	1042	0.895949	**MEL**	944	0.808638	**TSC**	590	0.482539
CFI	892	0.765153	**MEP**	1059	0.955379	**VET**	1023	0.913737
CGF	819	0.695238	**MER**	738	0.622222	**VFI**	669	0.562500
CGS	718	0.613333	**MFI**	960	0.825819	**VNI**	971	0.896603
CHA	677	0.566667	**MFS**	995	0.866320	**VSV**	948	0.818000
-CHI	913	0.833441	**MON**	1033	0.885802	**WEI**	773	0.655864
-CLO	456	0.443290	**MOR**	938	0.802340	**-WEN**	755	0.640693
CON	784	0.670229	**MSO**	822	0.694444	**YUG**	935	0.797884
CZP	885	0.800000	**MTF**	1083	0.942112	**ZON**	798	0.679089
DDR	968	0.850801	**MTN**	1049	0.927590			
DAC	977	0.841190	**MTT**	1015	0.883181			

APPENDIX D

Origin of 3-Letter Codes and Material Names

Code	Abbreviated Name	Full Name
ABW		Li-**A** (**B**arrer and **W**hite)
ACO	**AC**P-1 (**o**ne)	**A**luminium **C**obalt **P**hosphate - one
AEI	**A**lPO_4-18 (**ei**ghteen)	Aluminophosphate-eighteen
AEL	**A**lPO_4-11 (**el**even)	Aluminophosphate-eleven
AEN	**A**lPO-**EN**3	Aluminophosphate ethylenediamine (**en**) - three
AET	**A**lPO_4-8 (**e**igh**t**)	Aluminophosphate-eight
AFI	**A**lPO_4-5 (**fi**ve)	Aluminophosphate-five
AFN	**A**lPO_4-14 (**f**ortee**n**)	Aluminophosphate-forteen
AFO	**A**lPO_4-41 (**f**orty-**o**ne)	Aluminophosphate-forty-one
AFR	S**A**PO-40 (**f**o**r**ty)	**S**ilico-**A**lumino**p**hosphate-forty
AFS	M**A**PSO-46 (**f**orty-**s**ix)	**M**g**A**l(**P**,**Si**)O_4-46
AFT	**A**lPO_4-52 (**f**ifty-**t**wo)	
AFX	S**A**PO-56 (**f**ifty-si**x**)	**S**ilico-**A**lumino**p**hosphate-fifty-six
AFY	Co**A**PO-50 (**f**ift**y**)	
AHT	**A**lPO_4-**H**2 (**t**wo)	
APC	**A**l**P**O_4-**C**	
APD	**A**l**P**O_4-**D**	
AST	**A**lPO_4-16 (**s**ix**t**een)	
ASV	**A**SU-7 (**s**e**v**en)	**A**rizona **S**tate **U**niversity - seven
ATN	M**A**PO-39 (**t**hirty-**n**ine)	**M**g**A**l**PO**$_4$- thirty-nine
ATO	**A**lPO_4-31 (**t**hirty-**o**ne)	
ATS	M**A**PO-36 (**t**hirty-**s**ix)	
ATT	**A**lPO_4-12 (**t**welve)-**T**AMU	**A**l**PO**$_4$-12-**T**exas **A**&**M** **U**niversity
ATV	**A**lPO_4-25 (**t**wenty-fi**v**e)	
AWO	**A**lPO_4-21 (**t**wenty-**o**ne)	
AWW	**A**lPO_4-22 (t**w**enty-t**w**o)	
***BEA**	Zeolite **Be**t**a**	
BPH	**B**eryllo**p**hosphate-**H**	**B**eryllo**p**hosphate-**H**arvey (or **h**exagonal)
CAS	**C**esium **A**lumin**s**ilicate	
CFI	**C**IT-5 (**fi**ve)	**C**alifornia **I**nstitute of **T**echnology - five
CGF	**C**o**G**aPO-5 (**f**ive)	**C**obalt-**G**allium-Phosphate-**f**ive
CGS	**C**o**G**aPO-6 (**s**ix)	**C**obalt-**G**allium-Phosphate-**s**ix
-CLO	**Clo**verite	Four-leafed **clover** shaped pore opening
CON	**C**IT-1 (**on**e)	**C**alifornia **I**nstitute of **T**echnology - one
CZP		**C**hiral **Z**inco**p**hosphate
DDR	**D**eca-**d**odecasil 3**R**	**Deca**- & **dodeca**hedra, **3** layers, **r**hombohedral
DFO	**D**A**F**-1 (**o**ne)	**D**avy **F**araday Research Laboratory - one
DFT	**D**A**F**-2 (**t**wo)	**D**avy **F**araday Research Laboratory - two
DOH	**Do**decasil 1**H**	**Dodeca**hedra, **1** layer, **h**exagonally stacked
DON	UT**D**-1 (**on**e)	**U**niversity of **T**exas at **D**allas-one
EAB		TMA-**E** (**A**iello and **B**arrer)
EMT	**EM**C-2 (**t**wo)	**E**lf (or **E**cole Supérieure) **M**ulhouse **C**himie - two
ESV	**E**RS-7 (**s**e**v**en)	**E**ni**r**icerche-molecular-**s**ieve-seven
EUO	**EU**-1 (**o**ne)	**E**dinburgh **U**niverisity - one

Code	Abbreviated Name	Full Name
GON	**G**US-1 (**on**e)	**G**ifu **U**niversity Molecular **S**ieve - one
IFR	**I**TQ-4 (**f**ou**r**)	**I**nstituto de **T**ecnologia **Q**uimica Valencia - four
ISV	**I**TQ-7 (**s**e**v**en)	**I**nstituto de **T**ecnologia **Q**uimica Valencia - seven
ITE	**I**TQ-3 (**t**hr**e**e)	**I**nstituto de **T**ecnologia **Q**uimica Valencia - three
JBW		Na-**J** (**B**arrer and **W**hite)
KFI	Z**K**-5 (**fi**ve)	**Z**eolite **K**err - five
LOS	**Los**od	**Lo**w **sod**ium aluminosilicate
LTA	**L**inde **T**ype **A**	Zeolite **A** (Linde Division, Union Carbide)
LTL	**L**inde **T**ype **L**	Zeolite **L** (Linde Division, Union Carbide)
LTN	**L**inde **T**ype **N**	Zeolite **N** (Linde Division, Union Carbide)
MEI	ZS**M**-18 (**ei**ghteen)	**Z**eolite **S**ocony **M**obil - eighteen
MEL	ZS**M**-11 (**el**even)	**Z**eolite **S**ocony **M**obil - eleven
MFI	ZS**M**-5 (**fi**ve)	**Z**eolite **S**ocony **M**obil - five
MFS	ZS**M**-57 (**f**ifty-**s**even)	**Z**eolite **S**ocony **M**obil - fifty-seven
MSO	**M**CM-61 (**s**ixty-**o**ne)	**M**obil **C**omposition of **M**atter - sixty-one
MTF	**M**CM-35 (**t**hirty-**f**ive)	**M**obil **C**omposition of **M**atter - thirty-five
MTN	ZS**M**-39 (**t**hirty-**n**ine)	**Z**eolite **S**ocony **M**obil - thirty-nine
MTT	ZS**M**-23 (**t**wenty-**t**hree)	**Z**eolite **S**ocony **M**obil - twenty-three
MTW	ZS**M**-12 (**tw**elve)	**Z**eolite **S**ocony **M**obil - twelve
MWW	**M**CM-22 (t**w**enty-t**w**o)	**M**obil **C**omposition of **M**atter-twenty-two
NES	**N**U-87 (**e**ighty-**s**even)	**New** (ICI) - eighty-seven
NON	**Non**asil	**Nona**hedra, all **sil**ica composition
OSI	Ui**O**-6 (**si**x)	**U**niversity of **O**slo-six
OSO	**OS**B-1 (**o**ne)	Universities of **O**slo and Calif., **S**anta **B**arbara – one
-RON	**Ro**ggia**n**ite	
RSN	**R**UB-17 (**s**eventee**n**)	**R**uhr **U**niversity **B**ochum - seventeen
RTE	**R**UB-3 (**t**hr**e**e)	**R**uhr **U**niversity **B**ochum - three
RTH	**R**UB-13 (**th**irteen)	**R**uhr **U**niversity **B**ochum - thirteen
RUT	**RU**B-10 (**t**en)	**R**uhr **U**niversity **B**ochum - ten
SAO	**S**T**A**-1 (**o**ne)	University of **S**ain**t** **A**ndrews - one
SAS	**S**T**A**-6 (**s**ix)	University of **S**ain**t** **A**ndrews - six
SAT	**S**T**A**-2 (**t**wo)	University of **S**ain**t** **A**ndrews - two
SAV	Mg-**S**T**A**-7 (**s**even)	University of **S**ain**t** **A**ndrews - seven
SBE	UC**SB**-8 (**e**ight)	**U**niversity of **C**alifornia, **S**anta **B**arbara - eight
SBS	UC**SB**-6 (**s**ix)	**U**niversity of **C**alifornia, **S**anta **B**arbara - six
SBT	UC**SB**-10 (**t**en)	**U**niversity of **C**alifornia, **S**anta **B**arbara - ten
SFE	**S**SZ-48 (**f**orty-**e**ight)	**S**tandard Oil **S**ynthetic **Z**eolite - fourty-eight
SFF	**S**SZ-44 (**f**orty-**f**our)	**S**tandard Oil **S**ynthetic **Z**eolite - fourty-four
SGT	**S**i**g**ma-2 (**t**wo)	
STF	**S**SZ-35 (**t**hirty-**f**ive)	**S**tandard Oil **S**ynthetic **Z**eolite - thirty-five
STT	**S**SZ-23 (**t**wenty-**t**hree)	**S**tandard Oil **S**ynthetic **Z**eolite - twenty-three
TON	**T**heta-1 (**on**e)	
VET	**V**PI-8 (**e**igh**t**)	**V**irgina **P**olytechnic **I**nstitute - eight
VFI	**V**PI-5 (**fi**ve)	**V**irgina **P**olytechnic **I**nstitute - five
VNI	**V**PI-9 (**ni**ne)	**V**irgina **P**olytechnic **I**nstitute - nine
VSV	**V**PI-7 (**s**e**v**en)	**V**irgina **P**olytechnic **I**nstitute - seven
ZON	**Z**APO-M1 (**on**e)	(**Z**n,**A**l)$\mathbf{PO_4}$ -**M**ulhouse - one

ISOTYPIC MATERIAL INDEX

* Type materials are marked with an asterisk

Dodecasil-3C	**MTN**
ECR-5	**CAN**
ECR-18	**PAU**
ECR-30	**EMT/FAU**
*Edingtonite	**EDI**
*EMC-2	**EMT**
Encilite	**MFI**
*Epistilbite	**EPI**
ERB-1	**MWW**
*Erionite	**ERI**
*ERS-7	**ESV**
*EU-1	**EUO**
EU-13	**MTT**
*Faujasite	**FAU**
Fe-NU-1	**RUT**
*Ferrierite	**FER**
FU-9	**FER**
FZ-1	**MFI**
G	**SOD**
Ga-NU-1	**RUT**
Gallosilicate ECR-10	**RHO**
Gallosilicate L	**LTL**
GaPO-14	**AFN**
GaPO-34	**CHA**
GaPO-DAB-2	**ZON**
Garronite	**GIS**
Gaultite	**VSV**
Genthelvite	**SOD**
*Gismondine	**GIS**
*Gmelinite	**GME**
Gobbinsite	**GIS**
Gonnardite	**NAT**
*Goosecreekite	**GOO**
Gottardiite	**NES**
*GUS-1	**GON**
H1	**VFI**
Harmotome	**PHI**
Hauyn	**SOD**
Helvin	**SOD**
*Heulandite	**HEU**
High natrolite	**NAT**
High-silica Na-P	**GIS**
Holdstite	**MTN**
Hsianghualite	**ANA**
Hydroxo sodalite	**SOD**
ISI-1	**TON**
ISI-4	**MTT**
ISI-6	**FER**
ITQ-1	**MWW**
*ITQ-3	**ITE**
*ITQ-4	**IFR**
*ITQ-7	**ISV**
ITQ-9	**STF**
JDF-2	**AEN**
(K,Ba)-G,L	**LTL**
K-Chabazite, Iran	**CHA**
K-exchanged Heulandite	**HEU**
K-F	**EDI**
K-M	**MER**
K-rich gmelinite	**GME**
Kehoeite	**ANA**
KZ-1	**MTT**
KZ-2	**TON**
Large port mordenite	**MOR**
*Laumontite	**LAU**
Leonhardite	**LAU**
Leucite	**ANA**
*Levyne	**LEV**
*Li-A (Barrer and White)	**ABW**
Linde D	**CHA**
Linde F	**EDI**
Linde Q	**BPH**
Linde R	**CHA**
Linde T	**ERI/OFF**
*Linde Type A	**LTA**
*Linde Type L	**LTL**
*Linde Type N	**LTN**
Linde W	**MER**
Linde X	**FAU**
Linde Y	**FAU**
*Liottite	**LIO**
*Losod	**LOS**
*Lovdarite	**LOV**
Low-silica Na-P (MAP)	**GIS**
LZ-105	**MFI**
LZ-132	**LEV**
LZ-202	**MAZ**
LZ-210	**FAU**
LZ-211	**MOR**
LZ-212	**LTL**
LZ-214	**RHO**
LZ-215	**LTA**
LZ-217	**OFF**
LZ-218	**CHA**
LZ-219	**HEU**
LZ-220	**ERI**
MAP	**GIS**
*MAPO-36	**ATS**
*MAPO-39	**ATN**
MAPO-43	**GIS**
*MAPSO-46	**AFS**
Maricopaite	**MOR**
*Mazzite	**MAZ**
MCM-9	**VFI**
*MCM-22	**MWW**
*MCM-35	**MTF**
MCM-37	**AET**
MCM-58	**IFR**
*MCM-61	**MSO**
MeAPO-47	**CHA**
MeAPSO-47	**CHA**
*Melanophlogite	**MEP**

*Merlinoite	**MER**
Mesolite	**NAT**
Metanatrolite	**NAT**
*Mg-STA-7	**SAV**
MgAPO-50	**AFY**
Microsommite	**CAN**
MnAPO-11	**AEL**
Monoclinic ferrierite	**FER**
Monoclinic H-ZSM-5	**MFI**
*Montesommaite	**MON**
*Mordenite	**MOR**
MSC-1	**AEN**
Mutinaite	**MFI**
N-A	**LTA**
Na-B	**ANA**
Na-D	**MOR**
Na-P1	**GIS**
Na-P2	**GIS**
Na-V	**THO**
*Na-J (Barrer and White)	**JBW**
*Natrolite	**NAT**
NaZ-21	**LTN**
Nepheline hydrate	**JBW**
*Nonasil	**NON**
Nosean	**SOD**
NU-1	**RUT**
NU-3	**LEV**
NU-4	**MFI**
NU-5	**MFI**
NU-10	**TON**
NU-13	**MTW**
NU-23	**FER**
*NU-87	**NES**
Octadecasil	**AST**
*Offretite	**OFF**
Omega	**MAZ**
*OSB-1	**OSO**
P	**KFI**
Pahasapaite	**RHO**
*Partheite	**-PAR**
*Paulingite	**PAU**
Perlialite	**LTL**
Phi	**CHA**
*Phillipsite	**PHI**
Pollucite	**ANA**
PSH-3	**MWW**
Q	**KFI**
*Rho	**RHO**
*Roggianite	**-RON**
*RUB-3	**RTE**
*RUB-10	**RUT**
*RUB-13	**RTH**
*RUB-17	**RSN**
SAPO-5	**AFI**
SAPO-11	**AEL**
SAPO-31	**ATO**
SAPO-34	**CHA**
SAPO-35	**LEV**
SAPO-37	**FAU**
*SAPO-40	**AFR**
SAPO-42	**LTA**
SAPO-43	**GIS**
SAPO-47	**CHA**
*SAPO-56	**AFX**
Scolecite	**NAT**
Si-CHA	**CHA**
Sigma-1	**DDR**
*Sigma-2	**SGT**
Silica sodalite	**SOD**
Silicalite	**MFI**
Silicalite 2	**MEL**
Siliceous Na-Y	**FAU**
*Sodalite	**SOD**
Sr-D	**FER**
Sr-Q	**YUG**
SSZ-16	**AFX**
*SSZ-23	**STT**
SSZ-24	**AFI**
SSZ-25	**MWW**
SSZ-26	**CON**
SSZ-33	**CON**
*SSZ-35	**STF**
SSZ-42	**IFR**
*SSZ-44	**SFF**
SSZ-46	**MEL**
*SSZ-48	**SFE**
*STA-1	**SAO**
*STA-2	**SAT**
STA-5	**BPH**
*STA-6	**SAS**
Stellerite	**STI**
*Stilbite	**STI**
Svetlozarite (disordered variant)	**DAC**
Synthetic amicite	**GIS**
Synthetic analcime	**ANA**
Synthetic |Na-**|[**Al-Si-O**]-JBW**	**JBW**
Synthetic barrerite	**STI**
Synthetic brewsterite	**BRE**
Synthetic Ca-garronite	**GIS**
Synthetic cancrinite	**CAN**
Synthetic edingtonite	**EDI**
Synthetic epistilbite	**EPI**
Synthetic fault-free gmelinite	**GME**
Synthetic garronite	**GIS**
Synthetic gobbinsite	**GIS**
Synthetic gonnardite	**NAT**
Synthetic hsinghualite	**ANA**
Synthetic laumontite	**LAU**
Synthetic lovdarite	**LOV**
Synthetic melanophlogite	**MEP**
Synthetic merlinoite	**MER**
Synthetic mesolite	**NAT**

Synthetic natrolite	**NAT**
Synthetic offretite	**OFF**
Synthetic scolecite	**NAT**
Synthetic stellerite	**STI**
Synthetic stilbite	**STI**
Synthetic thomsonite	**THO**
Synthetic wairakite	**ANA**
*Terranovaite	**TER**
Tetragonal edingtonite	**EDI**
*Theta-1	**TON**
Theta-3	**MTW**
*Thomsonite	**THO**
Tiptopite	**CAN**
TMA sodalite	**SOD**
*TMA-E	**EAB**
TMA-gismondine	**GIS**
TMA-O	**OFF**
TNU-1	**CGS**
TPAF AlPO-5	**AFI**
TPZ-3	**EUO**
TPZ-12	**MTW**
Triclinic bikitaite	**BIK**
TS-1	**MFI**
TS-2	**MEL**
*Tschörtnerite	**TSC**
Tschernichite	***BEA**
TsG-1	**CGS**
TSZ	**MFI**
TSZ-III	**MFI**
Tugtupite	**SOD**
TZ-01	**MFI**
UCSB-3GaGe	**DFT**
UCSB-3ZnAs	**DFT**
UCSB-6Co	**SBS**
*UCSB-6GaCo	**SBS**
UCSB-6GaMg	**SBS**
UCSB-6GaZn	**SBS**
UCSB-6Mg	**SBS**
UCSB-6Mn	**SBS**
UCSB-6Zn	**SBS**
*UCSB-8Co	**SBE**
UCSB-8Mg	**SBE**
UCSB-8Mn	**SBE**
UCSB-8Zn	**SBE**
UCSB-10Co	**SBT**
*UCSB-10GaZn	**SBT**
UCSB-10Mg	**SBT**
UCSB-10Zn	**SBT**
*UiO-6	**OSI**
UiO-7	**ZON**
UiO-12-as	**AEN**
UiO-12-500	**AEN**
UiO-20	**DFT**
USC-4	**MFI**
USI-108	**MFI**
UTD-1	**DON**
*UTD-1F	**DON**
UTM-1	**MTF**
Vishnevite	**CAN**
*VPI-5	**VFI**
*VPI-7	**VSV**
*VPI-8	**VET**
*VPI-9	**VNI**
VS-12	**MTW**
VSV-7#	**VSV**
Wairakite	**ANA**
*Weinebeneite	**WEI**
Wellsite	**PHI**
*Wenkite	**-WEN**
Willhendersonite	**CHA**
*Yugawaralite	**YUG**
*ZAPO-M1	**ZON**
ZBH	**MFI**
Zeolite N	**EDI**
Zeolite W	**MER**
Zincophosphate X	**FAU**
ZK-4	**LTA**
*ZK-5	**KFI**
ZK-14	**CHA**
ZK-19	**PHI**
ZK-20	**LEV**
ZK-21	**LTA**
ZK-22	**LTA**
ZKQ-1B	**MFI**
ZMQ-TB	**MFI**
Zn-STA-7	**SAV**
ZnAPSO-40	**AFR**
ZSM-3	**EMT/FAU**
ZSM-4	**MAZ**
*ZSM-5	**MFI**
*ZSM-11	**MEL**
*ZSM-12	**MTW**
*ZSM-18	**MEI**
ZSM-20	**EMT/FAU**
ZSM-22	**TON**
*ZSM-23	**MTT**
ZSM-35	**FER**
*ZSM-39	**MTN**
ZSM-50	**EUO**
ZSM-51	**NON**
*ZSM-57	**MFS**
ZSM-58	**DDR**
ZYT-6	**CHA**